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Soil Survey of The Shoshone Area, Wyoming

By

T. J. DUNNEWALD, in Charge, and CARL PEARSON
University of Wyoming
and
JAMES THORP, E. J. CARPENTER
and E. G. FITZPATRICK
United States Department of Agriculture

Bureau of Chemistry and Soils

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SOIL SURVEY

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SOIL SURVEY OF THE SHOSHONE AREA, WYOMING

By T. J. DUNNEWALD, in Charge, and CARL PEARSON, University of Wyoming, and JAMES THORP, E. J. CARPENTER, and E. G. FITZPATRICK, United States Department of Agriculture

AREA SURVEYED

The Shoshone area includes the central and northeastern parts of Park County and the northern part of Big Horn County in northwestern Wyoming. (Fig. 1.) It comprises 886 square miles, or 567,040 acres.

The western boundary of the area is about 52 miles east of Yellowstone National Park. Boundary lines were drawn to include lands of this region now under irrigation and also those lands which, from the viewpoint of practical engineering and water resources, may be put under the ditch at a later period. The western part of the area borders Heart, Rattlesnake, and Cedar Mountains and extends southwest from Cedar Mountain to include a part of the developed lands bordering South Fork Shoshone River. From the western boundary the area extends eastward through Oregon Basin to R. 98 W., where it joins the Basin area.[1] The southeastern boundary is determined roughly by the outline of the proposed Oregon Basin division of the Shoshone irrigation project of the Bureau of Reclamation, United States Department of the Interior, but in several places it overlaps this line to some extent. To the northeast, the boundary reaches the Montana State line at Elk Basin and follows this line to a point about 4 miles northeast of Frannie, from which point it zigzags southeastward to within about a mile of Shoshone River and then extends northeastward 5 miles to meet Big Horn River which forms the extreme eastern boundary of the area. The northeastern part of the area is separated from the southeastern part by badlands and by a small range of mountains known as the McCollough Mountains.

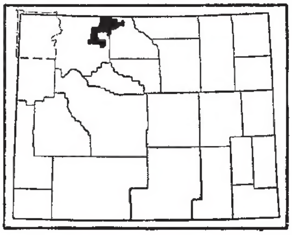


FIGURE 1.—Sketch map showing location of the Shoshone area, Wyoming

The Shoshone area is a part of the intermountain desert country, known as the Big Horn Basin, lying between the Big Horn Mountains and the main ranges of the Rocky Mountains.

[1] THORP, J., FITZPATRICK, E. G., DUNNEWALD, T. J., and GORSUCH, F. P. SOIL SURVEY OF THE BASIN AREA, WYOMING. (Unpublished manuscript.)

Within the area, the chief physiographic features consist of numerous alluvial terraces bordering Shoshone and Big Horn Rivers, broad alluvial fans lying between the uplands and the terraces, and rolling or hilly uplands, the underlying rocks of which are sandstones and shales. The alluvial terraces are very well defined, and the different levels are in most places separated by steep escarpments. The river terraces range from 10 feet above high water near Shoshone River to several hundred feet above high water on the Polecat Bench. The terraces along the smaller creeks have a much more restricted range in elevation.

The elevation at Cody is 4,984 feet. Bordering Shoshone River to the northeast the elevation gradually decreases, that at Powell being 4,389 feet, and at Lovell 3,825 feet. Bench marks on the Heart Mountain division of the Shoshone project show elevations ranging around 4,800 feet, and a marker on the southwestern end of the Polecat Bench gives the altitude as 5,174 feet. Just west of the Shoshone area the rise is very rapid, and elevations of more than 10,000 feet are reached within a very short distance.

Those parts of the Shoshone area where good lands have been put under irrigation are very thickly populated, whereas other parts, which have no water available, are practically uninhabited. In some places, where salty soils have been put under the ditch, the accumulation of alkali has forced the abandonment of lands formerly occupied by farmers. Where the soils under cultivation are fertile a farmstead is commonly seen on every 40 to 80 acres. The population of Park County, according to preliminary reports from the census of 1930,[2] is 8,207, of which probably more than 90 per cent reside in the Shoshone area.

The first lands in the area to be settled were along the river bottoms where water could easily be obtained for irrigation. The larger irrigable areas attracted settlers to the bench lands lying higher above the level of the streams.

Big Horn County was organized in 1897 from parts of Fremont and Johnson Counties, and Park County was organized from a part of Big Horn County in 1911. Cody, with a population of 1,800, is the county seat of Park County. The towns of Cody, Powell, Deaver, Cowley, and Lovell maintain good schools and churches and have water, natural-gas, and electric-light systems. Cody is a transportation and supply point for tourists entering Yellowstone National Park, and camp grounds and " dude ranches " are maintained for the accommodation of vacationists in the mountain valleys near this town. Modern free camp grounds for the accommodation of tourists are located in Powell and Lovell.

A branch of the Chicago, Burlington & Quincy Railroad, having its terminus at Cody and connecting with the main line at Frannie, furnishes transportation for the main part of the area, and the main line of the same system serves the eastern part of the area. Passenger accommodations are excellent over the branch line during the tourist season, but after the closing of Yellowstone National Park daily service is provided by an accommodation freight and passenger

[2] Soil survey reports are dated as of the year in which the field work was completed. Later census figures are given whenever possible.

train. On the main line through Lovell there is one passenger train a day in each direction. Bus service to and from Cody into Yellowstone National Park is well organized.

The Yellowstone Highway (United States Highway No. 20) connects Cody with Yellowstone National Park and with Greybull and points south and east. United States Highway No. 420 is a good graded road passing from Cody through Powell, Deaver, and Frannie to Billings, Mont. Another excellent road (United States Highway No. 310) connects Deaver with Lovell, Greybull, and points south and east. From Lovell, a good graded road extends eastward across Big Horn River and the Big Horn Mountains to Sheridan, Wyo.

Telephones are in general use throughout the developed parts of the area, and electricity for lighting and power, generated at the Shoshone Dam, is available throughout the more thickly settled parts. Schools, churches, and community halls are conveniently located for the use of the rural and urban districts. In many places children are transported in school busses to consolidated schools in the towns.

Local markets absorb most of the fruit and vegetable products of the area, and large quantities of these foods, especially fruits, are shipped in from outside points. Much of the wheat grown is milled locally, but some is shipped out. Hay crops are largely used locally, although large quantities of alfalfa meal are shipped out.

The principal products, such as sugar beets, seed beans, peas, potatoes, honey, wool, cattle, sheep, and dairy products, must be shipped to larger markets, such as Billings and Denver, to reach wholesale houses sufficiently large to handle them. The sugar beets are manufactured into sugar at Lovell, and the product is shipped to distant markets. The beet pulp is fed to cattle.

CLIMATE

The climate of the Shoshone area is distinctly seasonal. The summers are warm, with occasional days when the thermometer may register above 100° F. The hot spells are of short duration, however, and, as is characteristic of regions of high elevation, changes in temperature may be sudden and very pronounced. The mean summer temperature of the area is about 66°. An absolute minimum summer temperature of 23° has been observed at Cody. The fall months are warm and pleasant as a rule, but freezing weather may occur at any time during this season. The days are generally bright and clear, but an occasional cloudy or stormy day may occur in the fall. The winter months are cold. However, as the air is dry, the cold is not so penetrating as it would be in a moister climate. A minimum winter temperature of −51° F. has been recorded at Lovell. The mean temperature of the spring months is nearly the same as that of the fall months, but there are more stormy days in the spring.

The average length of the frost-free season at Cody is 114 days and at Lovell is 116 days.

The precipitation in the Shoshone area is so light that it is of little importance to the farmer, and irrigation is everywhere necessary for the production of agricultural crops. Cody has an average annual precipitation of 8.68 inches, Powell 5.44 inches, and Lovell 6.15 inches. Most of this falls during the spring, summer, and fall. This amount of moisture is only sufficient for the growth of desert-loving vegetation such as sagebrush, winter fat (sometimes called salt sage), and other desert shrubs. The average snowfall of the winter, as recorded at Cody, is only slightly more than that of fall and slightly less than that of spring.

Tables 1 and 2, compiled from records of the Weather Bureau, give climatic data for Cody and Lovell and are fairly representative of climatic conditions in the southern and northern parts of the area, respectively.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Cody, Park County, Wyo.*

[Elevation, 4,984 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1900)	Total amount for the wettest year (1923)	Snow, average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December	23.2	64	−31	0.34	(1)	0.71	5.0
January	23.5	60	−34	.26	0.45	(1)	3.7
February	24.4	65	−28	.34	.45	.27	2.9
Winter	23.7	65	−34	.94	.90	.98	11.6
March	33.2	74	−25	.45	(1)	.55	5.3
April	43.3	84	2	.90	2.27	1.08	5.7
May	51.5	91	22	1.13	.22	.70	1.6
Spring	42.7	91	−25	2.48	2.49	2.33	12.6
June	62.3	103	23	1.17	.27	1.69	.2
July	68.2	101	34	1.00	.50	1.85	.0
August	66.2	98	32	.82	.32	1.64	.0
Summer	65.6	103	23	2.99	1.09	5.18	.2
September	56.3	94	21	.98	.00	3.27	.7
October	44.9	84	−11	.82	.70	2.14	5.4
November	33.6	69	−23	.47	.03	.34	4.2
Fall	44.9	94	−23	2.27	.73	5.75	10.3
Year	44.2	103	−34	8.68	5.21	14.24	34.7

[1] Trace.

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Lovell, Big Horn County, Wyo.*

[Elevation, 3,825 feet]

Month	Temperature: Mean	Temperature: Absolute maximum	Temperature: Absolute minimum	Precipitation: Mean	Precipitation: Total amount for the driest year (1919)	Precipitation: Total amount for the wettest year (1898)	Precipitation: Snow, average depth
	°*F.*	°*F.*	°*F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	17.5	65	−43	0.24	0.34	0.03	2.6
January	15.6	60	−37	.47	.32	.06	5.7
February	22.1	62	−51	.19	.03	.12	1.9
Winter	18.4	65	−51	.90	.69	.21	10.2
March	32.1	78	−22	.25	(1)	.65	2.6
April	45.4	86	8	.59	.15	.15	.9
May	54.4	97	21	1.20	.42	4.83	.8
Spring	43.9	97	−22	2.04	.57	5.63	4.3
June	64.7	111	31	.73	.06	1.20	.0
July	70.1	106	33	.55	.05	.86	.0
August	67.5	102	28	.46	.12	.99	.0
Summer	67.4	111	28	1.74	.23	3.05	.0
September	57.4	97	17	.77	.50	.05	.1
October	45.0	82	0	.44	.46	.74	1.6
November	31.7	80	−17	.26	.04	.17	1.6
Fall	44.7	97	−17	1.47	1.00	.96	3.3
Year	43.6	111	−51	6.15	2.49	9.85	17.8

[1] Trace.

AGRICULTURE

When white men first entered this region, buffalo, deer, antelope, and other wild game were plentiful and roamed the hills and plains at will. Owing to the arid climate, the region did not offer much inducement to agricultural development, and for many years it was occupied only by hunters and trappers. A few settlers located along the creeks adjacent to the mountains in the forties, running cattle on the plains during the winter and in the mountains during the summer. However, it was not until after the Civil War, principally during the seventies, that settlement began in earnest. During this time settlers located along all the larger creeks of the area where water was available for livestock and where, as the seasons demanded, they could change their range from the plains to the mountains.

The grazing of cattle on the open range continued to be the foremost industry of the region for many years. About 1900 a great number of settlers located along the intermittent streams, and sheep were grazed over the ranges which were too barren and inaccessible for cattle. By 1910 practically every spring, creek, or water hole was preempted by stockmen. Since the introduction of sheep into the region, there has been a gradual change from cattle grazing to sheep grazing, until at the present time tax schedules show there

are about 30,000 head of cattle, 125,000 head of sheep, and 18,000 head of horses ranging over the plains and in the mountains adjacent to Cody.

Ever since the first settlement in this region some attempt has been made at irrigation. In general the settler attempted only to divert sufficient water to irrigate a small garden spot and field, where vegetables, wheat, and oats for home or neighborhood consumption were grown. Little attempt was made to produce hay to carry livestock through severe winter weather, though some cattlemen diverted water over the lands adjacent to the streams to improve the natural meadow.

It was not until about 1900 that serious attention was directed to diverting water from the larger streams for extensive irrigation development. In this year W. F. Cody (Buffalo Bill) and George T. Beck completed the construction of a canal taking water from South Fork Shoshone River to irrigate about 15,000 acres in the vicinity of Cody. Agricultural development under this project progressed steadily until at the present time it is thoroughly established.

In 1908 a part of the lands in the Garland division of the Shoshone project were put under irrigation by the United States Reclamation Service, and later all of this division and the Frannie division were placed under irrigation. The west end of the Willwood division was opened to settlement in the fall of 1927, and in the summer of 1928 there was a good grain yield on part of this land.

Dry farming has not been seriously attempted in this section because of the arid conditions prevailing. Irrigation has always been depended on for successful crop production, and since the beginning of irrigation on a large scale, alfalfa, wheat, and oats have been the leading crops of the area. Sugar beets, potatoes, and beans have taken a more important place in the last few years.

No figures are available dealing directly with the total agricultural products of the area. However, census figures for Park County give a basis for comparison of the extent and relative values of the different crops. In 1910 Park County embraced an area of 3,468,800 acres, of which 7.3 per cent was improved. There were 624 farms in the county, with an average of 95 acres of improved land a farm. Slightly more than one-half the farms reported the use of hired labor in 1909 at an average cost of slightly less than $1,200 a farm; less than one-half the farms reported the purchase of feeds, at a cost of $325 a farm; and three farms reported the purchase of fertilizer, to the value of $53 a farm. Approximately 93 per cent of the farms were operated by the owners in 1910 and about 78 per cent in 1920. In 1909 the value of all agricultural products was $1,941,037, to which four agricultural products contributed more than 90 per cent of the total value. Animals sold and slaughtered were valued at $881,115, hay and forage at $377,299, wool at $343,601, and cereals at $200,432.

All tame or cultivated hay crops occupied an area of 24,316 acres in 1909. Wheat occupied 4,326 acres, oats 360 acres, barley 227 acres, and corn 20 acres. There were 145 acres of sugar beets, 327 apple trees, and 108 plum trees reported.

In 1920 there were 839 farms in the county, with an average size of 341.1 acres, of which 106.9 acres were classed as improved land. The value of all agricultural products in 1919 was $7,783,884. The increased value over 1909 is due in part to the fact that in 1919 the value of all domestic animals, amounting to $3,989,418, was included in this total, whereas in 1909 only the value of those sold or slaughtered was included. The value of hay and forage in 1919 ($1,633,505) nearly equaled the combined value of all agricultural products in the county in 1909. Cereals were valued at $879,957, vegetables at $450,328, poultry and eggs at $128,375, dairy products at $75,658, and wool at $470,130.

Wheat and oats continued to be the leading cereals, occupying 16,802 and 5,691 acres, respectively, in 1919. Tame or cultivated grasses were reported on 37,253 acres, of which alfalfa occupied 31,188 acres. The acreage of wheat had increased about four times and that of alfalfa about twice over the acreage of 1909. Oats had fallen off in acreage to some extent. Potatoes occupied 1,400 acres, an increase of about 1,000 acres over 1909. Sugar beets were grown on 568 acres, an increase of about 400 acres over 1909. There was a large increase in the planting of apple trees in the decade, 2,753 trees of bearing age being reported in 1919.

The trend in agricultural development can be readily seen from the foregoing data and from the data given in Tables 3 and 4 on page 8. The production of hay and forage under irrigation and the running of sheep and cattle on the open range, to be fed during the winter and spring months on alfalfa and grain, continue to be the leading agricultural pursuits. Near Cody and on the lands farther east and northeast the growing of cash crops, including sugar beets, potatoes, and beans, is taking the lead. The production of poultry and poultry products is increasing and will doubtless continue to increase for some time. Dairying has increased, but with alfalfa one of the leading crops this industry should be developed to a much greater extent. The production of potatoes and sugar beets shows a normal steady growth. Some beans and corn have been grown in the area during late years, the former with a good degree of success. These cultivated crops are valuable additions to the agricultural program, and their culture could be further extended.

Throughout the area potatoes, beans, and corn are grown on the warm sandy soils in order to hasten maturity. Sugar beets produce better yields on the heavier-textured soils and are generally grown on such soils.

Alfalfa is cut on an average of twice a season near Cody and three times in the region between Ralston and Kane. It is brought from the fields on buck rakes and deposited on stackers which elevate it to the stacks. The hay is generally left in the stacks until it is used for feed, very little of it being baled for shipment to outside markets. Much of the crop is fed on the farm, the farmers feeding it out to sheep or cattle under contract. Cereals are cut with a binder, shocked, and threshed, and most of the grain is handled in bulk.

According to figures from local shipping associations, shipments of produce from Powell in 1927 included 1,081 carloads of baled hay, 414 carloads of alfalfa meal, 256 carloads of potatoes, 18 carloads of dry beans, 4 carloads of honey, 529 carloads of sugar beets,

5 carloads of dressed turkeys (about 9,000 birds), 25,000 chickens, 8,000 gallons of ice cream, and 162,000 pounds of butter.

A survey of agricultural production in the Garland division of the Shoshone irrigation project, conducted by agricultural agents of Park County, is summarized in Tables 3 and 4. The Garland division is the most highly developed part of the Shoshone area.

TABLE 3.—*Acreage, average acre yield, and acre value of crops in the Garland division of the Shoshone irrigation project in 1916 and 1926*

Crop	Acres		Average acre yield		Acre value	
	1916	1926	1916	1926	1916	1926
	Number	*Number*	*Bushels*	*Bushels*	*Dollars*	*Dollars*
Wheat	2,886	1,916	18.3	23.0	18.30	25.60
Oats	8,544	1,301	26.4	28.4	15.68	12.70
Barley	561	866	30.1	19.2	17.28	13.55
Corn	11	23	17	15	25.50	6.50
Beans	14	1,952	11.6	8.3	41.76	16.60
Potatoes	263	1,213	154	145	154.20	116.50
			Tons	*Tons*		
Sugar beets	885	3,051	11.1	10.8	73.48	91.90
Alfalfa hay	13,006	15,395	2.36	1.69	18.80	10.16
Miscellaneous hay crops	325	45	.78	1.1	5.72	3.00
Corn fodder	61	25	5.3	1.4	5.48	42.60

TABLE 4.—*Number and value of livestock in the Garland division of the Shoshone irrigation project, in 1916 and 1926*

Animals	Number		Value	
	1916	1926	1916	1926
			Dollars	*Dollars*
Hogs	3,367	847	28,754	9,464
Horses	1,870	1,633	235,040	99,695
Beef cattle	976	474	38,365	14,235
Dairy cattle	1,627	1,618	100,775	64,880
Sheep	1,645	7,934	10,749	48,568
Bees (colonies)	1,015	1,001	4,890	7,340

Farm buildings, though not elaborate, are serviceable. Barns are small, have little or no room for hay, and are used as shelter for livestock only during severe storms. Farm machinery is modern and sufficient. Work animals are of medium weight and well adapted to local requirements. The beef cattle on the range are largely of the Hereford breed, the bulls are well bred, and the herds are gradually being built up. Dairy animals for the most part are of poor quality, although there are a number of high-bred herds.

No definite system of crop rotation is followed. The land is generally kept in alfalfa for several years, after which it is put in wheat or oats for a period of two or three years, then back to alfalfa. Under this system of cropping the soils generally remain fertile, and little fertilizer is used. Too long periods of continuous cropping to alfalfa often result in depletion of available phosphates. Applications of superphosphate give good returns on many old alfalfa and sugar-beet fields. More frequent planting of cultivated crops and

shorter periods of alfalfa growing tend to prevent the development of the need for application of phosphates. Barnyard manure is generally applied to the sugar-beet fields or to grainfields. On the Shoshone project, alfalfa is followed by potatoes or beets, these in turn by grain, and then alfalfa again. Sugar beets are frequently grown two or more years in succession and are often followed by beans or peas.

Labor is plentiful and mostly of high quality. Many ranchers exchange labor and machinery during busy seasons. Most of the men employed on cattle and sheep ranches as well as on general farms are American born. Mexican labor is usually employed in the sugar-beet fields for thinning, weeding, and topping the crop.

Farms are of medium size, the average irrigated farm comprising about 60 acres. Most of the farms are operated by the owners, a few by tenants, and some of the larger livestock ranches by managers.

Land values range from $20 to $250 an acre, depending on location, improvements, and type of soil.

Irrigation water rates range from less than $1 an acre to $2.50.

SOIL SERIES AND TYPES

The soils of the Shoshone area are classified in series, types, and phases. A soil series includes several soil types, and a type may include several phases. A soil series is a group of soils which are essentially the same in every respect except in the texture of the surface soil. The series name is taken from the name of a locality near which the series was first mapped. A soil type is a member of a given series with a particular texture in the upper few inches. A phase is a local condition or deviation within a soil type. An example will further explain the meaning of the terms used. All soils in the Shoshone area having light grayish-brown surface soils, yellowish-brown subsurface soils, and subsoils which are full of white lime accumulations and are underlain at a depth ranging from 2 to 3 feet by river-worn gravel have been classified as belonging to the Ralston series. A soil of this series with a surface soil of fine sandy loam is known as Ralston fine sandy loam. If this soil type be locally poorly drained it is designated Ralston fine sandy loam, poorly drained phase.

In describing soil types the terms "profile" and "horizon" are frequently used. A soil profile is a vertical cross section such as is exposed in a road cut or along the edge of a vertical stream bank. A profile of most soils shows several more or less distinct horizontal layers. Most soils, except those on steep eroded hills and on river bottoms, have three main horizons. The topmost horizon is the part which is cultivated and hence is of most importance to the farmer, the middle horizon in the Shoshone area is rich in lime, and the third, or bottom, horizon is the parent material, or the material from which the soils have been formed.

The arable soils mapped in the Shoshone area have been classified in 7 series comprising 30 soil types and 15 phases. In addition, three classes of miscellaneous materials are mapped.

The soils of the Ralston series are very widely distributed and, all things considered, are the most valuable soils in the area. (Pl. 1, A.)

Every crop grown in this section of the country does well on Ralston soils. Potatoes, beans, peas, beets, alfalfa, and grains are the principal crops. The Gilcrest and the Billings soils are similar to the Ralston soils in crop adaptations. The Billings soils are more difficult to drain than the Ralston soils and are not so well adapted to potatoes and alfalfa, but they are better adapted to grains and they produce crops of beans and peas that equal and sometimes surpass those on Ralston soils. The Meeteetse soils are highly productive but are very inextensive. The Chipeta soils are very extensive and where not too shallow are very productive of alfalfa, grains, and beans, but over very large areas they are so shallow and rest on such impervious material that subdrainage is impossible and alkali accumulation is inevitable. (Pl. 1, B.) The Shoshone soils in some places produce good crops but are subject to alkali accumulation and are very difficult to drain because they lie so near the level of the streams. The Pierre soils are shallow and lie on salty shales and almost invariably become affected by alkali in a short time after they are irrigated.

In the following pages the soil types of each series are described and their agricultural utilization and possibilities are discussed. The acreage and proportionate extent of each soil are given in Table 5.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in the Shoshone area, Wyoming*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Ralston fine sandy loam	62,272	11.1	Chipeta very fine sandy loam	12,480	2.5
Poorly drained phase	448		Gravelly subsoil phase	1,600	
Ralston loam	49,088	9.0	Chipeta loam	21,504	4.1
Poorly drained phase	1,728		Shallow phase	1,536	
Ralston sandy loam	1,920	.3	Chipeta clay loam	14,528	2.7
Ralston silty clay loam	5,696	1.0	Playa phase	832	
Ralston gravelly loam	16,512	3.1	Chipeta loamy fine sand	19,520	3.4
Stony phase	1,088		Meeteetse fine sandy loam	3,008	.9
Ralston gravelly fine sandy loam	2,752	.5	Gravelly subsoil phase	2,496	
Ralston loamy fine sand	768	.1	Meeteetse silt loam	1,984	.9
Billings loam	28,800	5.4	Gravelly subsoil phase	3,072	
Gravelly subsoil phase	1,472		Meeteetse loam	704	.1
Billings fine sandy loam	30,464	5.5	Meeteetse clay loam	2,368	.4
Gravelly subsoil phase	576		Shoshone fine sandy loam	7,744	2.1
Billings clay loam	11,136	2.3	Terrace phase	576	
Poorly drained phase	1,984		Poorly drained phase	3,584	
Gilcrest sandy loam	5,056	.9	Shoshone loam	5,632	1.0
Gilcrest loam	3,392	.7	Shoshone clay loam	3,840	.7
Poorly drained phase	128		Pierre loam	5,888	1.0
Gilcrest fine sandy loam	10,816	1.9	Pierre clay loam	6,592	1.2
Gilcrest loamy fine sand	192	.1	Rough broken and stony land	133,952	23.6
Gilcrest silty clay loam	640	.1	Dune sand	640	.1
Chipeta fine sandy loam	64,128	12.1	River wash	1,792	.3
Gravelly subsoil phase	4,672				
Chipeta gravelly fine sandy loam	5,440	0.9	Total	567,040	......

RALSTON FINE SANDY LOAM

Ralston fine sandy loam is the second most extensive and the most important agricultural soil in the area. This soil, as well as the other members of the Ralston series, lies on river terraces or benches of the Big Horn Basin. Most of these benches are nearly flat, with a considerable slope downstream. They lie from 20 to several hundred feet above the present level of stream flow, and hence the soil ma-

terial has been in place long enough for the weathering agencies to have had a maximum effect.

In virgin areas the upper 6 inches of soil consists of pale grayish-brown fine sandy loam which shows pronounced lamination in the upper part. The soil is very friable and breaks up into a powdery material under slight pressure. When pulverized by cultivation it holds moisture fairly well. No visible lime has accumulated in this layer, but the reaction of the soil with dilute acid indicates that large quantities of lime carbonate are present. The soil between depths of 6 and 19 inches is light yellowish-brown or light grayish-brown friable and slightly compacted loam, streaked and blotched with a whitish amorphous accumulation of calcium carbonate which increases with depth. Scattered pebbles in this layer have coatings resembling whitewash on their undersides. This is a characteristic of practically all the terrace and upland soils in this part of the country. The material in this layer forms small, easily crushed clods. From a depth of 19 inches to about 40 inches is the layer of maximum calcium carbonate accumulation. The upper part of this layer consists of a mixture of amorphous powdery lime, sandy loam, and gravel, the proportion of gravel increasing with depth. The gravel, which are mainly of dark igneous material washed from adjacent mountains long ago, are coated on the sides and bottoms, some of them entirely, by whitish lime. The gravel in the upper part of this layer are very rotten but become less so at greater depths. Below a depth of 40 inches the visible accumulation of lime diminishes rapidly and generally disappears at a depth ranging from 4 to 5 feet, giving place to loose gravel and sand. (Pl. 1, C.) In many places the limy layer is much thinner than typical.

There is much variation in the thickness of the various layers. In many places the gravelly layer occurs at a depth of 15 inches or less. There is some variation also in the color of the surface soil, this apparently being caused by a slight difference in the color of the material from which the soil has been derived. When this soil is dry, a pale brownish-gray crust, one-fourth inch or less in thickness, forms on the surface. The gravel stratum underlying Ralston fine sandy loam and all other soils of the Ralston series lies on unevenly eroded sandstones and shales at a depth ranging from 4 to 20 or more feet. Where these bedrocks lie at great depth they have little effect on the soil, but where they are near the surface they interfere with underdrainage and the alkali salts which they contain are dissolved by irrigation waters and brought to the surface by capillary attraction or seepage.

Ralston fine sandy loam is very easily handled because of the sandy texture of the surface soil. All crops which grow in the area flourish on this soil, but the land is especially adapted to beans, peas, alfalfa, wheat, oats, and, to less extent, sugar beets. Beans produce from 1,000 to 2,500 pounds an acre, the last-mentioned yield being fairly common. Only in exceptionally unfavorable years does this soil produce as little as 1,000 pounds of beans an acre.

This soil, as well as all other soils of the Shoshone area, is deficient in nitrogen. Leguminous crops, such as sweetclover and alfalfa, are valuable in overcoming this deficiency, as these crops not only take

nitrogen from the air for their own use but leave fixed nitrogen in the soil for the following crop.

The soil occurs on river terraces throughout the area, and many bodies are very large. The largest continuous area, which occurs on Polecat Bench, covers many square miles, but it is not under cultivation at present.

Improved land of this kind varies in price, depending largely on the nearness to towns and railroads.

Ralston fine sandy loam, poorly drained phase.—The poorly drained phase of Ralston fine sandy loam is similar to the typical soil except that it has a thin black mucky layer, from one-half to 1 inch in thickness, on the immediate surface and generally shows some rust-brown mottling throughout the profile. It is very wet and supports a growth of wild barley, foxtail, horsetail, and marsh grasses. It is used mainly for pasture. In places the land is being drained, and such areas may become highly productive.

Areas of Ralston fine sandy loam, poorly drained phase, are small and few; the largest are just west of Penrose, south of Shoshone River.

RALSTON LOAM

Ralston loam, to a depth of 6 or 8 inches, consists of pale-brown or pale grayish-brown slightly calcareous loam which contains appreciable amounts of fine and medium sand and is friable and mealy. When dry the topmost surface soil has a pale brownish-gray calcareous crust, about one-fourth inch thick, underlain by a fine granular mulch. The subsoil to a depth ranging from 14 to 20 inches consists of very calcareous dull-gray loam. In undisturbed areas this material is dense and compact, without apparent structure, but it breaks down to a coarse cloddy structure under light pressure and when crumbled is granular, or mealy. Accumulation of lime carbonate gives this layer a speckled appearance. The soil is slightly porous, owing to small cavities left by the decay of plant roots. To a depth ranging from 48 to 96 or more inches the subsoil consists of dull grayish-brown or brownish-gray gravelly loam or gravelly sandy loam, the gravel and cobbles constituting from 40 to 60 per cent of the soil mass. The upper part of this layer is very calcareous, but the lime content decreases with greater depth. The subsoil rests on shale or sandstone at a depth generally greater than 6 feet and in some places at a depth of 15 or even 20 feet.

Ralston loam is one of the most prominently developed soil types of the area. It covers practically all the upper terrace north of Corbett and south of Eaglenest Creek. It occurs in many areas bordering Shoshone River between Cody and Kane, in large areas in the vicinity of Powell, Garland, Cowley, and Lovell, and in a great number of small areas north of Cottonwood Creek and southwest of Corbett.

In some places erosion has altered the terrace form of this soil, though in general it still retains a smooth, gently sloping surface. The eroded areas are rolling or hilly, in some places being too badly broken and dissected to be of agricultural value. Under natural conditions drainage is good or excessive. When irrigated, some of the soil requires artificial drainage, especially where it occurs immediately below higher irrigated terraces.

This is a valuable soil in the production of crops suited to local climatic conditions and is especially adapted to grains, alfalfa, beets, and potatoes. Average yields, based on estimates obtained from farmers, are wheat, 40 bushels to the acre; alfalfa, 2 tons; beets, 13 tons; potatoes, 300 bushels; and beans, 1,500 pounds. Yields of 20 tons of beets, 450 bushels of potatoes, 60 bushels of wheat, and 100 bushels of barley have been reported. The highest yields are commonly obtained on land that has been well manured.

When first put under irrigation this soil should be liberally supplied with organic matter. Good cultural practices and rotating with alfalfa or sweetclover at frequent intervals will aid in maintaining the soil in a permanently productive state. The feeding of sheep, hogs, and cattle on the ranches is a highly desirable practice. It is believed that the dairy and poultry industries could be developed to a greater extent.

Ralston loam, poorly drained phase.—The upper 6 or 8 inches of the poorly drained phase of Ralston loam consists of dull-brown or dark grayish-brown loam in which faint drab or rust-brown mottlings are apparent in some places. The subsoil, to a depth ranging from 15 to 20 inches, consists of very calcareous dull-brown or dark grayish-brown heavy loam or clay loam which contains numerous gray and rust-brown mottlings. The material in this layer is rather compact. Gravel constitutes from 40 to 60 per cent of the subsoil mass. The subsoil rests on dark grayish-brown gravelly sandy loam or loam which, in turn, rests on sandstone or shale at a depth ranging from 50 to 72 inches.

Soil of this phase is not extensive. It occurs bordering the bluff line east of Cody and in numerous small spots in the irrigated lands. The surface of the land ranges from smooth and gently sloping to flat or slightly depressed. Drainage is very poor, and most of the areas contain much alkali. This soil is used as pasture land or in the production of oats, alfalfa, or wild hay. In places the land is being drained, and doubtless the drained areas will be fully as productive as typical Ralston loam in a few years.

RALSTON SANDY LOAM

Ralston sandy loam resembles Ralston fine sandy loam in every respect except in the texture of the topsoil which is about 6 inches deep and consists of pale grayish-brown sandy loam.

This soil supports a natural vegetation of sagebrush, winter fat (salt sage), rabbit brush, and a sparse growth of grama and needle grass in places. It is valued for the same crops as Ralston fine sandy loam but is not quite so productive. Small scattered areas occur chiefly along the south terraces of Shoshone River between the Willwood diversion dam and Lovell.

RALSTON SILTY CLAY LOAM

The surface soil of Ralston silty clay loam consists of a 6 or 8 inch layer of slightly calcareous pale grayish-brown or light grayish-brown silty clay loam or clay loam. It has a pronounced crust and mulch on the surface, and below this the soil is granular and works up rather easily to a good seed bed. Under virgin conditions it is low

in organic matter. The upper part of the subsoil is compact, is somewhat grayer than the surface soil, and contains gray flecks and soft nodules of lime carbonate. A great number of small holes or pores, formed by the decay of plant roots, occur in this layer. At a depth ranging from 15 to 20 inches the subsoil changes to grayish-brown or brownish-gray compact gravelly clay loam or loam which is highly calcareous. The lime decreases somewhat in quantity with depth. Gravel and cobbles increase in number, however, until at a depth of 5 or more feet they constitute from 40 to 50 per cent or more of the soil mass. The soil rests on bedrock of shale or sandstone at an average depth of about 7 feet.

This soil is developed in rather large areas northeast of Beck Lake, east of Cody, and near Powell and Garland. A few small bodies are scattered throughout the area. The surface is smooth or slightly depressed, but a few areas which are slightly eroded are undulating. Drainage is good under virgin conditions, but much of the soil needs drainage when under irrigation.

Most of the soil is under cultivation and produces yields of wheat, oats, and alfalfa similar to those obtained on Ralston loam. Sweet corn, potatoes, and root crops give good yields under proper care. Small acreages are in currants, cherries, and apples, which yield well in favorable seasons. High yields of sugar beets are obtained when conditions are favorable for a good stand. The formation of a hard crust on the surface of the soil makes it difficult for seedlings to force their way to the surface. This soil is very productive but rather difficult to handle because of its heavy character.

The natural vegetation consists mainly of winter fat (salt sage), with sagebrush and a little grama in some places.

RALSTON GRAVELLY LOAM

The 6 or 8 inch surface soil of Ralston gravelly loam consists of light-brown or pale grayish-brown mellow gravelly loam. The upper part of the subsoil is moderately compact dull brownish-gray or dull grayish-brown rather calcareous loam or clay loam which has a slight suggestion of a jointed or columnar structure. The lower part of the subsoil, extending to a depth of 40 or more inches, consists of brownish-gray compact very calcareous gravelly sandy loam or gravelly loam. Gravel and cobbles, which consist of rounded waterworn granite, limestone, and dark igneous rocks, constitute from 40 to 60 per cent of the soil mass of this layer. Below this depth the material is less calcareous and somewhat less compacted or cemented. The alluvial deposits rest on sandstone or shale at a depth ranging from 6 to 20 or more feet.

This soil occurs only on the alluvial terraces bordering Shoshone River. Several different-sized areas are in the vicinity of Newton Lake and to the south along the foot of Rattlesnake and Cedar Mountains, several areas border Shoshone River northeast of Cody, and many areas, ranging in size from 10 to 60 or more acres, are on the upper terrace northwest of Corbett associated with Ralston loam. Areas of this soil follow the edge of the terraces along Shoshone River to its confluence with Big Horn River and along the south edge of Polecat Bench nearly to Frannie.

Ralston gravelly loam occupies alluvial terraces of gently sloping or almost flat relief. Some eroded areas have a rolling or hilly

relief. Drainage is excessive under natural conditions. Under irrigation this soil requires more water than the heavier soils of this series.

Less than 1 per cent of the soil is cultivated, and fair yields of wheat, oats, and alfalfa are obtained. Alfalfa, on account of its deep rooting system, is better adapted to this soil than are the shallower-rooted crops. Uncultivated areas are covered with a sparse growth of native grasses, sagebrush, and rabbit brush.

Ralston gravelly loam, stony phase.—The stony phase of Ralston gravelly loam has an 8 or 9 inch surface soil of light grayish-brown or light-brown stony gravelly loam. The subsoil consists of light grayish-brown or light brownish-gray stony gravelly loam which is rather compact and highly calcareous. Stone and gravel increase in quantity with depth until they occupy from 50 to 65 or more per cent of the soil mass. The stones are angular or subangular and most of them range from 6 to 18 inches in diameter, and the soil can not be cultivated before removing the larger stones. Under cultivation it would be very leachy and droughty.

Areas of this soil are comparatively small. They occur southeast and northwest of the Irma Flats, near the bases of Cedar and Rattlesnake Mountains, and south of Newton Lake. The soil has a terracelike or in places a fanlike relief. Drainage is excessively developed, and none of the soil is under cultivation or is suited to agriculture. Native grasses, sagebrush, and rabbit brush maintain a scanty growth over the land.

RALSTON GRAVELLY FINE SANDY LOAM

Ralston gravelly fine sandy loam is very light textured pale brownish-gray gravelly fine sandy loam to a depth of about 20 inches. At this depth some accumulation of lime occurs, but this is not pronounced. There is practically no compaction in most of this soil as mapped in the Shoshone area. The substratum consists of a deposit of sandy gravel which is made up largely of dark-colored igneous rocks.

Areas of this soil occur northeast of the Willwood Dam, southwest of Frannie and Penrose, and north of Kane.

Natural vegetation consists of sparse growths of sagebrush, grama, and rabbit brush. The soil is very leachy and is of very little agricultural value, as almost continuous irrigation is required to keep it moist. Sparse crops of alfalfa and sweetclover may be obtained. An attempt was made to grow apple trees on this soil near the confluence of Shoshone and Big Horn Rivers, but the attempt resulted in failure. It is recommended that the land be left in its natural condition as irrigation will not make it productive. Under irrigation, water is sure to seep from this soil to neighboring good lands and cause them to accumulate alkali.

RALSTON LOAMY FINE SAND

The upper 27 inches of Ralston loamy fine sand consist of pale yellowish-brown loamy fine sand which effervesces with acid increasingly with depth. A few pebbles, which occur in this layer, have a coating of white lime accumulation on their undersides. Between depths of 27 and 40 inches the body color of the soil remains the same but has a yellow or white mottling of lime accumulation. The

texture is somewhat heavier than in the layer above, being very light fine sandy loam. Below this layer is grayish-brown loamy sand, mixed with a large proportion of loose gravel, which extends to a depth ranging from 4 to 10 feet, where it is underlain by sandstone and shale bedrock.

This soil supports a natural growth of sagebrush, rabbit brush, and sparse growths of grama and needle grass. It is deficient in organic matter, but when watered and fertilized with manure or green manure it produces good yields of alfalfa, beans, and peas. Owing to its light texture and the underlying layer of gravel, a very large amount of water is needed to keep the soil moist enough for growing crops. This factor reduces the cash value of the land greatly. There is danger of seepage from areas of this soil lying above good soil on lower terraces, with a resulting accumulation of alkali in the lower-lying associated soils unless drainage ditches are provided to carry off the waste water.

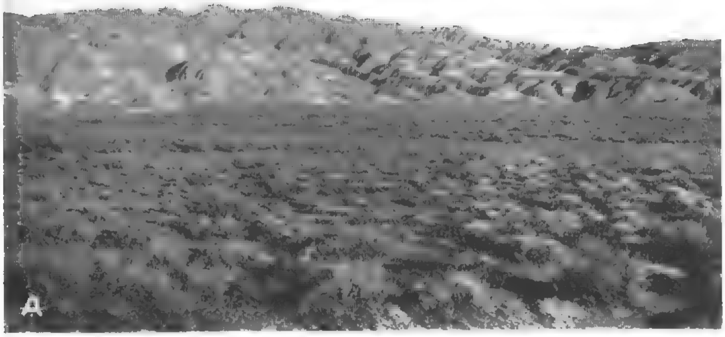
Ralston loamy fine sand is not extensive but is widely distributed throughout the terrace lands of the area. It occurs southwest of Ralston, south of Powell, southwest of Byron, and southeast of Lovell. About 20 per cent of the land is under cultivation.

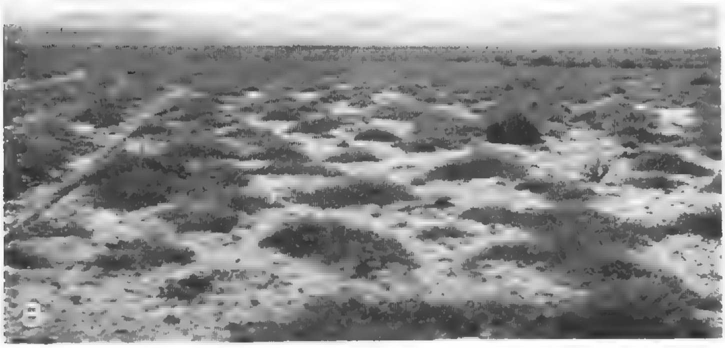
BILLINGS LOAM

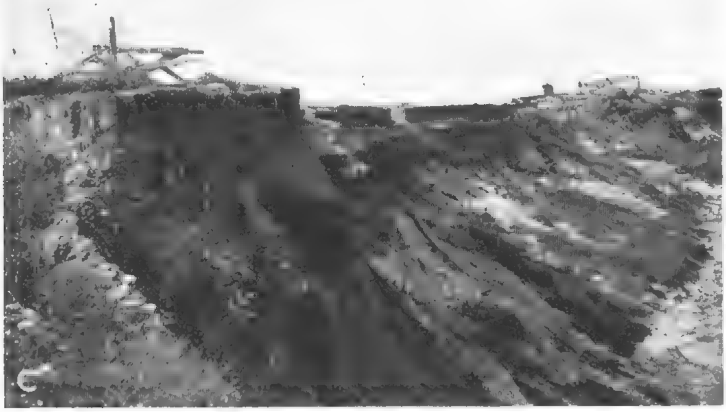
Billings loam is locally noted as an especially good sugar-beet soil. Although it is not so easily cultivated and drained as the Ralston soils it will produce just as good crops.

The upper one-fourth inch of soil is a crust of pale yellowish-brown loam or very fine sandy loam which is laminated and finely granular, with flattened granules. It contains large amounts of alkali salts and is calcareous. The next one-half inch layer is heavy-textured light-brown laminated fine sandy loam, below which, to a depth of 6 inches, the soil consists of interstratified layers of yellowish-brown loam, fine sandy loam, and very fine sandy loam and contains many plant roots extending predominantly in a horizontal direction between the layers. Between depths of 6 and 16 inches is yellowish-brown light-textured loam which breaks into irregular clods about 2 inches in diameter. This layer is fairly compact and contains some alkali salts, and plant roots are irregularly distributed. Between depths of 16 and 25 inches is pale yellowish-brown loam containing small spots of limy material, many irregularly distributed plant roots, and, in places, small amounts of gypsum. The next layer, which extends to a depth of 36 inches, is pale yellowish-gray fine sandy loam or very fine sandy loam containing a little visible lime and a few plant roots. Below this to a depth of 4 or more feet are alternating layers of varicolored sand, fine sand, and fine gravel, with various other textural combinations. There is, however, no important gravel layer. Where stream channels have cut into the soil it stands erect, with a tendency to form large columns.

The color varies somewhat, depending on the character of the sandstones and shales from which the soil has developed. In some places the soil has an olive-drab tint, in other places it has a pink cast, and in a few areas between Cowley and Frannie it is dark olive drab.







A, Natural vegetation on Ralston soils in foreground and McCollough Mountains, composed of stratified shales and sandstones, in background; B, natural vegetation on Chipeta soils; C, profile of Ralston soils occupying terrace along Shoshone River

Billings loam, together with other members of the Billings series, occurs between the sandstone and shale uplands and the river terraces, on broad moderately sloping alluvial fans. It also occurs along intermittent drainage ways in terracelike positions and in places as true river terraces.

The natural vegetation consists chiefly of a sparse covering of winter fat (salt sage) and a scattered growth of grasses and various weeds.

About 80 per cent of the Billings loam is under cultivation, and most of the remainder will probably be irrigated and farmed in the future. The soil is deficient in organic matter, as are all soils of the area, but this may be overcome by the growing and turning under of green-manure crops and by the use of stable manure. The soil is especially adapted to grains, alfalfa, sugar beets, and beans. Yields of 60 bushels of wheat to the acre, 100 bushels of both oats and barley, 20 tons of beets, and 2,000 pounds of beans are not uncommon. Selling prices of this soil vary, depending on the locality. In some places, where the underlying bedrock has interfered with subdrainage, alkali has accumulated in considerable quantities, and the soil will be of little value unless the alkali can be washed out.

Billings loam, gravelly subsoil phase.—The surface soil of the gravelly subsoil phase of Billings loam consists typically of a 6-inch layer of pale brownish-gray somewhat laminated and granulated strongly calcareous loam, with a scattering of gravel on the surface. Between depths of 6 and 18 inches the material is slightly compact pale yellowish-brown loam with large white or pink splotches of lime accumulation. Many grass and winter-fat (salt sage) roots permeate this layer. Between depths of 18 and 25 inches is splotched yellowish-brown and grayish-white gritty loam containing many lime and gypsum accumulations. Below this and extending to a depth of 3 or 4 feet is a layer of gravelly sandy loam which contains some lime and gypsum. This layer rests on sandstones and shales.

Soil of this phase has many points of similarity with typical Ralston loam, but it averages much shallower and the gravelly layer is not loose as in the Ralston soil. The interstices are filled with soil, and drainage waters would have a more difficult passage through this layer than they do through the gravel layer in the Ralston soil.

This is an inextensive soil. Several areas lie north and west of Cowley. The relief is terracelike.

The land supports a natural growth of winter fat (salt sage), shadscale, grama, and some sagebrush.

As this soil is shallower than the typical soil it is valued somewhat lower. It must be drained to insure against the accumulation of alkali. About 60 per cent of the land is under cultivation, and the same crops are grown as on the typical soil.

BILLINGS FINE SANDY LOAM

Billings fine sandy loam is developed along the edges of the river terraces adjoining the uplands, along the intermittent streams and draws, and in low places in the uplands.

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The topmost one-fourth inch of Billings fine sandy loam is a crust of pale grayish-brown very fine sandy loam which is laminated and contains small flattened granules. Below this to a depth of 4 inches the material is light grayish-brown finely granular and laminated fine sandy loam. The lamination decreases with depth, and the color becomes browner. This layer is very friable and is easily broken into a loose mulch which consists of small somewhat flattened granules. A few plant roots are seen in this layer. Between depths of 4 and 12 inches the soil is light yellowish-brown fine sandy loam which is rather friable and less compact than the material in the layer below. It is full of plant roots and breaks into small irregular easily crumbled clods. The next 12-inch layer is light yellowish-brown rather compact loam, containing a few small flecks and spots of lime in places. The soil material in this layer breaks into small irregular clods. It is permeated by plant roots but to less extent than the layer above. From a depth of 24 to a depth of 36 or more inches is brown sandy loam containing some fine gravel. This material is rather hard and compact when dry. Beneath this and extending to the underlying rock the material is stratified and of various textures. The whole profile is calcareous, but lime does not occur in sufficient quantities to be noticeable to the naked eye. Areas of this soil occurring on the low terraces bordering Shoshone River contain a more definite accumulation of lime than do most of the areas mapped.

Where this soil can be irrigated it is highly valued, particularly for sugar-beet, bean, and alfalfa production. Beets produce as much as 20 tons and beans from 1,500 to 2,000 pounds an acre. Less trouble with alkali salts is experienced on this soil than on the Chipeta soils. Improved Billings fine sandy loam commands a good price, provided there is no accumulation of alkali. Approximately 90 per cent of the land is under cultivation.

This soil is very widely distributed, particularly through the central and eastern parts of the area. A total of 47.6 square miles is mapped. The large bodies on the broad alluvial fans between the terraces and the uplands are covered with a growth of winter fat, pricklypear, and grama, and many of the narrow strips along the smaller creeks and draws support a sagebrush and grass vegetation. Where not under the ditch the land is used as winter pasture for sheep.

Billings fine sandy loam, gravelly subsoil phase.—To a depth of 6 inches the gravelly subsoil phase of Billings fine sandy loam consists of pale brownish-gray calcareous fine sandy loam containing scattered gravel and many grass and winter-fat roots. A very thin crust and mulch has formed on the surface. Between depths of 6 and 15 inches is light yellowish-brown fine sandy loam containing large splotches of white lime accumulation in places. This layer contains many roots and root holes which give the soil a porous character. A slight tendency to compaction occurs in this layer which is the most compact of the soil profile. Between depths of 15 and 24 inches is splotched yellowish-brown and grayish-white gritty loam containing roots and root channels as in the material above. This is the layer of maximum lime accumulation. The next layer consists of gravelly sandy loam having about the same

color as the layer above and containing much accumulated lime and a little gypsum. The gravel consists mainly of limestone and quartzite. Sandstone and shale occur at a depth ranging from 3 to 4 feet.

This soil occurs only along Whistle Creek in the east end of the Willwood division of the Shoshone project and has not at this time (1927) been put under irrigation. It should prove to be a good soil when drained to prevent the accumulation of alkali, and will probably be nearly as productive as typical Billings fine sandy loam. The land slopes gently and is suitable for irrigation, and ditches have already been constructed. It is being used at present for sheep pasture during the winter. The natural vegetation on this soil is about the same as that on the typical soil, with the addition of shadscale.

BILLINGS CLAY LOAM

Billings clay loam under virgin conditions is characterized by a surface crust, one-eighth inch or less in thickness, which is smooth and hard on the surface but is rough and consists of loosely cemented soil granules on the underside. It is light brownish gray on the immediate surface but becomes somewhat darker colored beneath. The material is silty clay loam or clay loam in texture, and beneath the crust is a fluffy granular dull grayish-brown mulch of similar texture. The granules composing the mulch are irregular in shape and are about the size of a wheat grain or slightly smaller. They decrease in size with depth until at a depth of about 2½ inches they give way rather abruptly to firm light grayish-brown clay loam which is dense and cloddy when dry but mealy and friable when moist. The subsoil to a depth ranging from 28 to 36 inches consists of very calcareous and rather compact light brownish-gray or grayish-brown clay loam or clay of smooth silty texture. A few gray mottlings or specks of lime carbonate, or in places gypsum, occur in this layer. The material can be crumbled to a fine granular condition under moderate pressure. The lower subsoil layer, or parent material, to a depth ranging from 6 to 15 feet, consists of dull grayish-brown moderately compact and moderately calcareous silty clay loam or clay loam. In some areas this material contains accumulations of gypsum. The parent soil rests on sandstone or shale.

The color of the soil varies as does that of Billings loam. Large areas between Cowley and Frannie approach the Pierre soils in character and are olive drab or dark olive drab in color. Little or no lime has accumulated in the soil in this part of the area.

Billings clay loam is widely distributed. An area embracing several square miles extends from a point 1½ miles south of Corbett northward to within a mile of Eagle School. Other large areas are north of Powell, at Garland, and adjacent to Deaver, Cowley, and Frannie. A small area borders Sage Creek (near Cody) just above its junction with Shoshone River, and another small area is just west of Eagle School.

The soil has a smooth gently sloping surface which in places is almost flat. Local areas in the vicinity of stream ways are somewhat eroded. Under natural conditions the soil is well drained, though when irrigated it shows poor subdrainage in places. It absorbs moisture readily and retains it well, and in other ways is well suited to irrigation practices.

Billings clay loam is derived from partly weathered alluvial deposits of mixed origin. The natural vegetation consists of rabbit brush and sagebrush, on the higher better-drained areas, and winter fat on the flatter areas. About 30 per cent of the land is under irrigation and is devoted to the same crops as are grown on Billings loam. Yields of sugar beets are somewhat greater on this soil than on the loam member of the series, and the yields of other crops are similar. The heavy texture of the soil makes it difficult to cultivate and to obtain stands of plants having small seeds.

Billings clay loam, poorly drained phase.—Soil of this phase resembles typical Billings clay loam in profile except that it shows some rust-brown mottlings throughout and there is a slight accumulation of organic matter on the surface in distinctly marshy areas. The surface soil is puddled and very plastic when wet but becomes finely granular when dry. When it dries it bulges and becomes very porous, giving rise to the name "self-rising land." All areas contain large accumulations of alkali. This soil occurs mainly in natural depressions which are very difficult to drain by any means. Even where drainage ditches are constructed the soil is generally so puddled that it is impossible to successfully drain it. As mapped, this poorly drained soil includes a few small areas of poorly drained Billings loam and Billings fine sandy loam.

The natural vegetation is mainly greasewood, and, where the soil is marshy, many cattails and other marsh plants grow. The soil has little agricultural value.

The larger areas of this soil occur west and south of Lovell and near Byron. A few small bodies are scattered over the rest of the area.

The results of mechanical analyses of samples of several layers of typical Billings clay loam are given in Table 6.

TABLE 6.—*Mechanical analyses of Billings clay loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
480508	Surface soil, ⅛ to ½ inch	0.0	0.1	0.2	2.9	19.5	43.8	33.4
480509	Subsurface soil, ½ to 10 inches	.0	.0	.1	2.2	28.5	40.8	28.4
480510	Subsoil, 10 to 33 inches	.0	.0	.0	2.7	27.5	45.4	24.6
480511	Subsoil, 33 to 96 inches	.5	.9	.4	3.1	22.6	56.8	15.9

GILCREST SANDY LOAM

The principal areas of Gilcrest sandy loam are in the central part of the Heart Mountain division of the Shoshone irrigation project. The typical profile herewith described was observed in sec. 26, T. 55 N., R. 101 W. The first inch of soil is grayish-brown fine sandy loam containing a small quantity of medium sand. There is a slight tendency to lamination, with fine flattened granules which crumble into single grains under slight pressure. A slight but noticeable amount of organic matter is present. Between depths of 1 and 10 inches is rich-brown sandy loam, very slightly compacted and becoming lighter in color with depth. There is no definite structure in the material other than a slight tendency to form small weak columns.

Grass roots penetrate this layer promiscuously. The next layer, extending to a depth of 21 inches, consists of heavy sandy loam with a body color of grayish white which is strongly mottled with brown, owing to the downward penetration of material from the upper layers through root holes and insect burrows. The grayish-white color is caused by the presence of large quantities of amorphous chalky lime-carbonate deposits. On a freshly cut surface this layer tends to break vertically. The next layer to a depth of 28 inches shows little change from the layer above except that the texture is slightly heavier and more lime is accumulated in the soil. Many grass roots are present in this layer as well as in the one above. Between depths of 28 and 36 inches is pale grayish-yellow sandy loam which is rather sticky when wet but very loose and friable when dry. It contains much amorphous lime. From this depth to a depth of 48 or more inches light-textured gravelly loam occurs. Much lime is present between the pebbles, which are entirely covered with the deposit, the coating being heavier on the under sides than on the upper. The gravel consists mainly of limestone and dolomite with some quartzite, chert, and igneous rocks interspersed. Below the zone of lime accumulation the gravel are little altered from their original condition. In the upper layers of this soil a small percentage of lime-coated gravel occurs.

The depths of the various layers differ greatly with the locality. In some places, where the soil occurs on a gentle slope, the depth to lime may be only 5 or 6 inches, whereas in areas which have a flat or basinlike relief the depth to lime may be from 18 to 24 inches. The other layers vary accordingly.

Most of this soil has good natural drainage so that little difficulty should be experienced with alkali accumulation when the land is irrigated. However, a few places show alkali salts at the surface, and a few "greasewood spots" indicate the presence of soluble salts which would be injurious to the growth of farm crops.

The natural vegetation on Gilcrest sandy loam consists of grama, sagebrush, and pricklypear. Most of the soil is still in virgin condition and affords excellent pasture for sheep and cattle.

Gilcrest sandy loam should prove to be a productive soil when it is placed under irrigation. Most of this soil on the Heart Mountain division of the Shoshone project lies on a smooth gently sloping alluvial fan, and on many of the units it will not be necessary to level the land or clear it of sagebrush. It should produce excellent yields of beans, peas, alfalfa, potatoes, and grains. There is enough grass sod on most of it to furnish enough organic matter for most crops for the first year or two. Although no figures are available, it appears that the soils in the central part of the Heart Mountain division, which is that part immediately northeast of Heart Mountain, receive much more rainfall than those farther east. This has produced a grass vegetation, with its accompanying accumulation of organic matter in the soil. The surface soil of this soil is distinctly darker colored than the surface soils of members of the Ralston series.

GILCREST LOAM

Gilcrest loam strongly resembles Ralston loam in surface soil characteristics, but in most places it does not contain enough lime car-

bonate in the upper 6 or 8 inches to effervesce with dilute hydrochloric acid, and this layer contains much more organic matter than the corresponding layer of Ralston loam. The organic matter gives the soil a light-brown color. Subsoil characteristics of the two soils are practically identical.

Gilcrest loam supports a growth of grama, needle grass, and much sagebrush. It occurs in slightly depressed areas in association with Gilcrest sandy loam on the Heart Mountain division of the Shoshone irrigation project. This soil is less extensive than Gilcrest sandy loam. It should prove well adapted to alfalfa, sweetclover, beans, potatoes, small grains, and other crops which are grown in the area. It will probably be slightly more productive than Ralston loam.

Gilcrest loam, poorly drained phase.—The poorly drained phase of Gilcrest loam occurs in a few depressions of the Heart Mountain division of the irrigation project. It is darker colored than typical Gilcrest loam, and the subsoil contains some rust-brown and gray mottlings. The water table lies within a depth of 30 or 40 inches from the surface. This soil contains harmful quantities of soluble salts in many places, and drainage will be necessary before the land can be successfully cultivated.

GILCREST FINE SANDY LOAM

Gilcrest fine sandy loam resembles Gilcrest sandy loam in every respect except in its slightly coarser texture to plow depth. In value and adaptability to crops it is similar to that soil.

Areas occur in association with Gilcrest sandy loam near Heart Mountain. The soil supports a natural growth of grama, needle grass, and sagebrush.

GILCREST LOAMY FINE SAND

The upper 30 inches of Gilcrest loamy fine sand is light yellowish-brown loamy fine sand containing little lime carbonate in the upper part of the layer. It differs from Ralston loamy fine sand chiefly in that it is slightly darker colored and contains less lime carbonate. The subsoil layers are practically identical with those of Ralston loamy fine sand.

This soil occurs in association with other soils of the Gilcrest series on the Heart Mountain irrigation unit. It is very inextensive. It supports a growth of needle grass and grama, with a scattering of sagebrush and rabbit brush. The value of the land should be slightly greater than that of Ralston loamy fine sand because of its greater content of organic matter, but it will always require an excessive amount of irrigation water. Applications of stable manure and the plowing under of cover crops will improve this soil by increasing the nitrogen content and water-holding capacity.

GILCREST SILTY CLAY LOAM

Gilcrest silty clay loam is similar in general characteristics and profile to Ralston silty clay loam except that it has a slightly higher organic-matter content, darker-brown color, and more leached condition of the surface soil which is typically noncalcareous. This soil is inextensive and occurs in association with other soils of the Gilcrest series in the Heart Mountain division of the irrigation project.

CHIPETA FINE SANDY LOAM

Typical Chipeta fine sandy loam, to an average depth of 8 inches, consists of light grayish-brown calcareous mellow fine sandy loam having a thin crust and mulch on the surface. The surface soil is slightly laminated and works up readily under cultivation to a mellow friable seed bed. It is very low in organic matter. However, a few areas which support a fair stand of grass have a 1 or 2 inch surface layer that is slightly darker colored than the material beneath, owing to an accumulation of organic matter. The subsoil to a depth ranging from 20 to 30 inches consists of brownish-gray or yellowish-brown slightly cemented or compacted fine sandy loam which breaks up, when disturbed, into coarse clods. The material is apparently without definite structure, though cracks or partings occur irregularly distributed through the soil material. The subsoil is very calcareous, the lime appearing as flecks and soft nodular accumulations on the broken faces of clods. The various clods appear to be made up of a great number of granules separated from one another by numerous irregular or tubular-shaped pore spaces which facilitate the movement of air and water through the soil. The lower subsoil layer, to a depth ranging from 30 to 40 inches, consists of grayish-brown fine sandy loam or loam which is moderately calcareous but lacks visible evidence of lime accumulation. In many places this layer has a white or pink gypsum accumulation which is firm and rather dense, having few visible pore spaces. Under slight pressure the material of this layer crumbles to a fine granular structure. It grades into bedrock of shale or sandstone at an average depth of about 36 inches. The weathered soil averages deeper east of Cody in the Oregon Basin country and much shallower in the Willwood and Frannie divisions of the Shoshone project.

This is the most extensive soil in the Shoshone area. The largest areas are east of Sage Creek (west) and in the Willwood and Frannie divisions of the Shoshone project. Smaller bodies are widely scattered throughout the area.

As mapped, the soil includes small areas in which the weathered soil material is shallower than typical. Such areas are in sec. 21, T. 52 N., R. 99 W., 4½ miles east of Cody, about 4 miles south of Cody, and along Sage Creek 3½ miles southeast of Beck Lake.

Areas of Chipeta fine sandy loam range from smooth and fanlike to rolling or hilly, too steep and broken to allow agricultural development. In general, this soil occupies the lower slopes which have a smooth surface well adapted to irrigation practices.

The soil material is derived from sandstone and shale. The material of the topmost surface soil has, in most places, been transported by surface creep or running water down the fan slopes, but the lower and dominant layers are mainly residual from the underlying shale and sandstone materials.

The soil under virgin conditions supports a growth of sagebrush, winter fat, and native grasses. Less than 1 per cent of the land is under cultivation and is devoted to grain or alfalfa production. Wheat yields from 30 to 40 bushels an acre and oats from 80 to 100 bushels. Alfalfa is cut on an average of twice a season and yields about 2 tons an acre. A few local poorly drained areas of the soil

are under irrigation, and these areas give much trouble on account of alkali accumulation. Owing to the close proximity of the sandstones and shales, most of this soil is likely to become affected by alkali accumulations under irrigation. The danger from alkali is less in the sloping areas than in level areas.

Irrigated land of this kind, where no alkali has accumulated, sells at a fairly good price. Higher prices are sometimes asked for the better-improved ranches. Unimproved lands not within proposed irrigation projects are valuable only for the grazing they afford. Such lands are mostly open-range country in Government ownership.

Most of the undeveloped Chipeta fine sandy loam should remain in its original condition because of the danger of alkali accumulation. The soil can be improved by the addition of organic matter, and careful use of water will tend to minimize drainage and alkali problems.

Chipeta fine sandy loam, gravelly subsoil phase.—The gravelly subsoil phase of Chipeta fine sandy loam has a 7 to 9 inch surface soil of light grayish-brown slightly calcareous, mellow, fine sandy loam which in most places contains some gravel though not in sufficient quantity to interfere with cultural operations or to greatly modify the physical character of the soil. Small gravelly mounds at the mouths of prairie-dog holes dot the surface of the land in most places. The upper subsoil layer consists of light grayish-brown or brownish-gray moderately calcareous and slightly compacted fine sandy loam or loam. This material contains a few gravel which increase in quantity with depth until, at an average depth of about 20 inches, the subsoil is compact brownish-gray gravelly loam or gravelly fine sandy loam. This material is very calcareous, and the gravel are more or less completely incrusted with lime. The gravelly material continues to a depth ranging from 36 to 48 inches, and it rests on partly weathered shale or sandstone material which grades into the parent rock at a slightly greater depth.

This phase of soil occurs east of Cody. A small area lies 5 miles north of Kane.

The relief ranges from fanlike to slightly hilly or rolling. The surface is smooth except in locally eroded areas, and the soil would be well suited to irrigation practices were it not for the danger of alkali accumulation. Drainage is good under natural conditions but would probably not be sufficient under irrigation.

This soil is developed on transported material derived largely from shales and sandstones. It is well weathered and contains, in the deeper part of the soil profile, a slight amount of soil of residual character. The gravel contained in the soil are largely of limestone origin, together with smaller quantities of quartzite and basic and acid igneous rocks.

Sagebrush and native grasses occupy 90 per cent of the land. The remainder is under irrigation and is used in the production of wheat, oats, and alfalfa. Crop yields are good though slightly less than on typical Chipeta fine sandy loam. Soil of the phase is valued almost the same as the typical soil. Most of the land lies in the Oregon Basin division of the Shoshone project and is not for sale prior to irrigation development.

CHIPETA GRAVELLY FINE SANDY LOAM

The surface soil of Chipeta gravelly fine sandy loam to a depth ranging from 6 to 9 inches consists of light grayish-brown gravelly fine sandy loam, which as a rule has a slight organic-matter accumulation in the upper 1 or 2 inches of soil. It is only slightly calcareous, is granular and friable, absorbs moisture readily, and works up to a fine-granular structure under cultivation. The subsoil to a depth ranging from 12 to 15 inches consists of slightly calcareous and moderately compact light grayish-brown or brownish-gray loam. When disturbed it breaks to a small cloddy structure, and the clods can be readily pulverized in the hand. The lower subsoil layer to a depth ranging from 30 to 48 inches consists of very calcareous grayish-brown or brownish-gray compact gravelly clay loam or loam. Below this is partly weathered shale or sandstone which grades quickly into the unweathered bedrock. The parent shales and the weathered soil material directly overlying them in most places contain appreciable quantities of alkali salts.

The largest areas of Chipeta gravelly fine sandy loam are in secs. 1 and 2, T. 52 N., R. 100 W., northwest of Byron, southwest of Penrose, and northwest of Kane. Several areas occur at wide intervals throughout the uplands of the area.

The areas of this soil range from smooth gently sloping terrace-like areas to others of rolling or hilly character. Most of the soil has a smooth surface well suited to irrigation practices. Erosion has resulted in local areas of irregular or broken relief. Drainage courses are deeply intrenched between steep banks, and this soil is generally separated from areas of associated soils by steep hills or bluffs, from 10 to 50 feet in height, which have been formed by erosion.

The stone and gravel in this soil are angular or subangular and of limestone and ironstone origin. Although this soil is regarded as consisting mainly of residual materials, in the Shoshone area the surface soil is derived mainly from weathered old alluvial deposits transported by surface wash and by the present or former streams and superimposed over the shales and sandstone underlying this region.

The natural vegetation consists of sagebrush and grasses. This soil is not farmed, as water for irrigation is not available. Most of the areas are open range and are pastured to sheep or cattle. Under irrigation the soil should prove productive, but it would require more frequent irrigation than heavier-textured soils. Drainage would also be necessary to insure against alkali accumulation. Areas of this soil within the proposed Oregon Basin division of the Shoshone project are in Government ownership and not available for settlement before being declared open to entry and settlement. Soil areas not in the project can be purchased at very low prices.

CHIPETA VERY FINE SANDY LOAM

The surface soil of Chipeta very fine sandy loam to a depth ranging from 5 to 7 inches consists of light brownish-gray or light grayish-brown slightly calcareous very fine sandy loam which is low in organic matter but is mellow and absorbs moisture readily.

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It should be an easy soil to cultivate and irrigate, and under cultivation it should retain moisture well. Local areas have a smooth hard surface crust, about one-eighth of an inch thick, which is rough and uneven on the underside, due to clinging granules of soil. Beneath the crust is a soft fluffy layer of mulch flocculated into fine granules which decrease somewhat in size with depth until firm soil is reached at an average depth of one-half inch or slightly less.

The upper subsoil layer consists of grayish-brown or brownish-gray loam or light clay loam which is more calcareous than the surface soil and slightly more compact. The material breaks up granular under slight pressure. In the lower part of this layer a few flecks of lime carbonate are present as coatings on scattered granules of soil, and a few pore spaces and tubular cavities appear. In general, the pore spaces are about the size of a pin or slightly smaller. From a depth of 9 or 10 inches to 18 or 22 inches the subsoil consists of very calcareous slightly cemented loam or clay loam which is mottled or flecked with lime-carbonate accumulations throughout. The soil in this layer appears to be made up of small granules separated by irregular-shaped or tubular pore spaces, most of which are no larger than a pin in diameter. The tubular spaces are probably root cavities which have not been altered since the decay of the roots. This layer is marked by irregularly occurring cracks or joints in the soil, along which blocks or clods of the material may be separated. The joints do not have the appearance of being coated with colloidal material carried from the surface, though in the upper part of the subsoil there is a faint suggestion of colloidal deposition along joints. Roots penetrate this layer to less extent than the layers above. The larger roots penetrate the soil in all directions, whereas the small fibrous roots follow seams or joints and are wrapped around the larger soil particles. The cementing material binding the granules is weaker than that binding the particles within the granules, as clods break around rather than across the individual granules. The crushed soil of this layer is slightly grayer than the broken faces of clods.

The lower subsoil layer grades into slightly browner material which is more dense and is without visible pore spaces and without visible evidence of lime accumulation. When tested with dilute acid it effervesces freely. This material is loam or very fine sandy loam in texture and is lenticular or laminated in structure, the various lenses or laminations being horizontal. Some mottling of yellow or dark drab occurs, owing to the presence of partly weathered shale or sandstone fragments. Bedrock of shale or sandstone occurs at a depth ranging from 26 to 40 inches.

Chipeta very fine sandy loam is extensively developed in the Oregon Basin and in the eastern part of the surveyed area. Few bodies occur elsewhere.

This soil joins on the east with a few small areas of Chipeta fine sandy loam of the Basin area. In that area the very fine sandy loam of the Chipeta series was included with the fine sandy loam, owing to its inextensive occurrence.

This soil has a fanlike or rolling to hilly relief. In general the surface is smooth and gently sloping, and the soil is well suited to

irrigation practices. Except in locally depressed areas and small inclosed basins, drainage is well developed.

Sandstones and shales have contributed very largely to the soil materials of this soil. Though the surface soil is derived mainly from weathered transported materials, the soil in the deeper part of the profile has resulted mainly from the weathering in place of the underlying bedrock.

The natural vegetation consists largely of sagebrush and grama. Some winter fat grows in places. None of the soil is under cultivation at the present time, although it lies largely within the proposed Oregon Basin division of the Shoshone irrigation project.

Under cultivation, the addition of organic matter would be beneficial to this soil. Care must be exercised in the economical use of irrigation water, as the shales underlying the soil carry appreciable quantities of alkali salts and give them up very readily.

Chipeta very fine sandy loam, gravelly subsoil phase.—The gravelly subsoil phase of Chipeta very fine sandy loam to a depth ranging from 6 to 9 inches consists of light grayish-brown or light brownish-gray mellow very fine sandy loam which is only slightly calcareous. A few limestone gravel occur over the surface, especially in the vicinity of animal burrows, where the gravel have been brought up from the subsoil. The upper part of the subsoil to a depth ranging from 12 to 16 inches is light grayish-brown loam or very fine sandy loam containing a few gravel. The material is slightly compact and appreciably more calcareous than the surface soil. The subsoil becomes more gravelly with depth until the material consists of brownish-gray very calcareous gravelly loam or light gravelly clay loam. Partly weathered sandstone or shale material, which overlies the parent bedrock, occurs at an average depth of about 40 inches.

Soil of this phase is not extensive in the area. One of the largest bodies is 1½ miles southeast of Mountain View School near Cody. Another body is in secs. 17 and 18, T. 52 N., R. 99 W. The relief of the soil is fanlike or in places ranges from rolling to hilly. The surface is smooth, moderately sloping, and well adapted to irrigation practices, and drainage is well developed in most places. This soil would require slightly more water under irrigation than the typical soil. It is low in organic matter which should be supplied by green-manure crops or other organic manures when the land is under cultivation.

The soil materials of this soil are of mixed origin, though they are recognized as being largely from shales and sandstones. They have been transported to their present position largely through the agency of running water, though surface creep and wind action have also contributed to their formation to some extent.

Sagebrush and native grasses constitute the vegetation on this soil in its virgin condition. None of the land is under cultivation. When irrigated it should prove well adapted to the crops suited to local climatic conditions.

Table 7 shows the results of mechanical analyses of samples of the surface soil, the subsurface soil, and the subsoil of typical Chipeta very fine sandy loam.

TABLE 7.—*Mechanical analyses of Chipeta very fine sandy loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
480533	Surface soil, 0 to 5 inches	0.4	0.7	1.4	30.4	37.2	20.9	9.7
480534	Subsurface soil, 5 to 9 inches	.3	.4	1.1	31.0	35.7	20.3	11.8
480535	Subsoil, 9 to 18 inches	.3	.5	1.0	28.8	41.6	19.7	8.1
480536	Subsoil, 18 to 26 inches	.0	.3	.4	9.6	15.6	50.3	24.4

CHIPETA LOAM

To a depth of 6 or 8 inches Chipeta loam consists of dull brownish-gray or light grayish-brown mellow loam which is low in organic matter. A surface crust and mulch, generally not more than one-half inch thick, covers the surface in most places. The material in the upper subsoil layer is slightly compact and more calcareous than the surface soil, and it grades abruptly at a depth of 10 or 12 inches into dull brownish-gray very compact and calcareous heavy loam or clay loam. Numerous gray lime-coated granules give this layer a speckled appearance. A few soft lime-carbonate accumulations occur in the larger root cavities. Owing to the cementing action of the lime, the soil granules are united into firm masses that break along occasional joints or cracks into large clods or blocks. The decay of roots has left a great number of pore spaces in the soil, with the result that air and water circulate freely. The pore spaces may be tubular but more commonly are small irregular cavities about the size of a grain of wheat. At an average depth of about 30 inches the subsoil becomes less compact and cemented. The lime flecks and nodules disappear and the pore spaces gradually decrease in number until, just above bedrock, they are absent. In many places this layer contains white or pink accumulations of gypsum crystals. The soil material in this lower subsoil layer is brownish-gray or grayish-brown loam or light clay loam. It is typically without gravel, though as mapped small areas are included in which gravelly subsoils occur. It grades into partly weathered sandstone or shale which overlies unweathered bedrock at an average depth of about 40 inches. This depth varies greatly with the locality, bedrock in many places lying at a depth of 20 inches.

Chipeta loam occurs in several bodies of different sizes throughout the upland parts of the area. One of the largest bodies is in the Oregon Basin, and several bodies are in the vicinity of Sage Creek (west), on the eastern border of the Irma Flats, near Beck Lake southeast of Cody, and in the Willwood and the Frannie divisions of the Shoshone project. Several small areas are north of Cottonwood Creek. Areas in which conspicuous amounts of gravel are present in the subsoil occur mainly from 2 to 5 miles north of Deaver, east and northeast of Frannie, and north and northwest of Cowley.

The surface of this soil is prevailingly smooth and well suited to irrigation practices. A few areas are rolling or hilly and in places too rough or stony for cultivation. Drainage is generally fair under natural conditions, though under irrigation most of the soil would probably become affected by alkali in a short time. In local areas

drainage problems have already developed. One such area covers about 1 square mile 2 miles southeast of Powell, and smaller areas are north and east of Powell. In fact, artificial drainage is impractical on most of the soil because the impervious sandstones and shales lie so near the surface.

Chipeta loam is of mixed origin. The surface soil materials have been transported to their present position largely through the agency of water, though in part from surface creep and wind action. The deeper materials have been formed in place from the underlying shales and sandstones. The natural vegetation is scattered and consists largely of sagebrush and winter fat which grows mainly on areas containing slight quantities of alkali. The concentration of alkali is rarely sufficient to be harmful to plant growth under natural conditions. Less than 5 per cent of Chipeta loam is cultivated. Alfalfa, oats, and wheat give good yields when properly cared for and where alkali has not accumulated.

Chipeta loam, shallow phase.—The shallow phase of Chipeta loam, to a depth of 6 or 8 inches, consists of grayish-brown or dull brownish-gray loam which in places closely approaches silt loam or silty clay loam in texture. The surface soil contains little or no organic matter and is rather calcareous. The subsoil consists of slightly grayer material than the surface soil, of clay loam or silty clay loam texture. It is very compact and contains numerous gray flecks and soft nodules of lime carbonate. It breaks into coarse clods or blocks which are penetrated in all directions by irregular or tubular pore spaces. At an average depth of about 18 inches the soil rests on shale or sandstone rock.

A large body of this shallow soil occurs in the Oregon Basin along the south boundary of the area. Smaller bodies are north of Cody. Most of the land is rolling or hilly. Because of the shallowness of the soil and the prevalence of large amounts of soluble salts in the underlying shales, this soil is not well suited to irrigation.

The land is very sparsely covered with sagebrush, rabbit brush, and winter fat, and much of it is barren of vegetation. None of it is under cultivation.

CHIPETA CLAY LOAM

Under virgin conditions a crust and mulch structure is typically developed over the surface of Chipeta clay loam. The crust is from one-eighth to three-sixteenths inch thick and consists of light brownish-gray clay loam which is smooth and firm on the surface but becomes more granular and less cemented directly beneath the surface film. On the underside it is a rough, irregular mass of granules, slightly cemented together. The crust checks into various-shaped blocks which have from four to eight faces and are generally from 2 to 3 inches in diameter. The granular underside of the crust grades off into a mass of small, loose, fluffy granules. This material is of slightly browner color than the surface crust and ranges from three-sixteenths to one-fourth inch in thickness. It changes abruptly to firmer and more closely packed granular light grayish-brown or brownish-gray clay loam. At an average depth of about 8 inches the surface soil is underlain by compact slightly cemented clay loam or clay which continues to a depth ranging from 28 to 34 inches.

This layer is very calcareous and contains a great number of gray lime-carbonate coated granules and soft gray nodules which have formed in small cavities in the soil. There is no definite arrangement of cleavage planes or joints in this layer, but when disturbed it breaks up into large clods or blocks which crush to a granular structure. Owing to a great number of pore spaces the material has a spongelike appearance under a magnifying glass. The lower subsoil layer is browner, slightly lighter textured, and less compact than the overlying layer and breaks up to a lenticular or laminated structure. It rests on bedrock at a depth ranging from 40 to 50 inches.

Chipeta clay loam occupies the flatter valley slopes and also occurs in basinlike areas. The largest body is 3 miles southeast of Cody, and a number of smaller areas occur in this same vicinity. Other areas are in and near secs. 14 and 23, T. 52 N., R. 100 W., and in the Oregon Basin.

Areas of this soil have a flat basinlike or in places a gently sloping fanlike relief. The surface is smooth and would require very little preparation for irrigation. Drainage ranges from fair to poor. Under irrigation difficulties can be expected on low-lying areas, owing to poor drainage and the accumulation of alkali salts.

The natural vegetation consists of winter fat, rabbit brush, and sagebrush. About 2 per cent of the soil is under cultivation and returns good yields of wheat, oats, and alfalfa.

Chipeta clay loam, playa phase.—The playa phase of Chipeta clay loam consists of 8 or 10 inches of light brownish-gray or grayish-brown heavy plastic clay, underlain by brownish-gray somewhat lighter textured extremely compact and slightly cemented clay which contains a great amount of lime-carbonate accumulation. The soil material rests on the sandstone or shale bedrock which underlies this region.

Soil of the playa phase occurs in several small bodies in the southern, eastern, and northern parts of the area. The largest body is in the Oregon Basin, and smaller areas are south of Cody. The land occupies small inclosed flat basins having very poor drainage, which even under irrigation would be of no agricultural value. Water, ranging from a few inches to a foot or more in depth, stands over the land during the winter. The soil supports no vegetation except a few annual weeds during the summer.

CHIPETA LOAMY FINE SAND

The upper 25 inches of Chipeta loamy fine sand is pale grayish-yellow loamy fine sand which when dry shows many black specks. The material in this layer is calcareous, but the lime is not visible. The wind shifts the soil material more or less, the shifting being partly checked by vegetation. Between depths of 25 and 30 inches the soil is pale brownish-yellow somewhat compacted or slightly cemented loamy fine sand. Scattered stone fragments show lime incrustation on their undersides, and the soil itself effervesces with acid. Below this layer and extending to a depth of 38 inches is pale grayish-yellow very fine sandy loam splotched with white accumulations of lime. There is a slight tendency to lamination in this layer, and the soil mass breaks into irregular clods. At a depth of

about 40 inches is rotten sandstone rock impregnated with white lime deposits in the upper part. The thickness of the soil layers varies greatly, and bedrock occurs at a depth ranging from 2 to 5 feet.

The natural vegetation consists mainly of rabbit brush, with some sagebrush and grama. This soil is rather extensive, large areas being located north and northwest of Byron and north and east of Garland. Very little of it is under cultivation, and irrigation of much of it would not be advisable because the soil would require a very large amount of water to keep it moist enough for crops. The soil is likely to blow badly after being plowed. Its present use is mainly for sheep pasture.

MEETEETSE FINE SANDY LOAM

The surface soil of Meeteetse fine sandy loam to a depth ranging from 5 to 7 inches consists of pale reddish-brown mellow slightly calcareous fine sandy loam. The soil is low in organic matter but is friable and absorbs moisture readily. The upper part of the subsoil to a depth of 8 or 10 inches consists of pale reddish-brown or pale brownish-red slightly compact granular loam which is moderately calcareous. This material changes rather abruptly to pale reddish-brown extremely compact heavy loam or clay loam which has a jointed structure and breaks into irregular-shaped clods or blocks marked with gray flecks or small soft nodules of lime-carbonate accumulations. In some places the accumulation of lime is less prominent. As characteristic of weathered soils in this region, the layer of lime accumulation contains a great number of irregular or tube-shaped pore spaces between the partly cemented soil granules. At a depth ranging from 26 to 30 inches this layer changes abruptly to pale reddish-brown compact dense loam or sandy loam in which there is no visible evidence of lime accumulation or of tubular or irregular-shaped pore spaces. This material rests on sandstone or shale bedrock at a depth ranging from 3 to 10 feet.

Meeteetse fine sandy loam is developed in a number of small areas in the southern and eastern parts of the Shoshone area. One of the largest bodies and several smaller ones occur in the vicinity of the point at which United States Highway No. 20 leaves the eastern boundary of the area. A number of small bodies occur along Dry Creek (west), Oregon Coulee, and Sulphur Creek, and north of the confluence of Shoshone and Big Horn Rivers.

Most areas of this soil have a gently sloping fanlike relief, though the soil also occurs on rolling or hilly areas in some places too rough, eroded, and stony for cultivation. The rough areas include some undifferentiated soils of the Greybull series. Surface drainage in most places is well developed, and the soil is well suited to irrigation, but, as with all other soils of this region, some trouble may be expected from accumulation of alkali in imperfectly drained local areas.

Meeteetse fine sandy loam is derived from red sandstone and shale materials which have been redeposited in the form of broad alluvial fans. The deposits have weathered in place to a greater or less degree.

The vegetation consists of sagebrush, rabbit brush, winter fat, and native grasses. Little of the soil is under cultivation, but where irri-

gated it is very productive, producing all crops common to the region. Most of the land is in Government ownership and not open to settlement at the present time.

Meeteetse fine sandy loam, gravelly subsoil phase.—The gravelly subsoil phase of Meeteetse fine sandy loam has a pale reddish-brown fine sandy loam surface soil, from 6 to 8 inches deep, overlying a slightly compact calcareous upper subsoil layer which, at a depth ranging from 15 to 18 inches, grades into pale reddish-brown compact gravelly loam. The material is highly calcareous and the gravel are more or less incrusted with lime. The gravelly subsoil continues to a depth ranging from 36 to 60 inches, where it is underlain by shale or sandstone bedrock. The gravel are small or medium-sized angular or subangular limestone or acid igneous rocks.

This gravelly soil occurs in secs. 3 and 15, T. 52 N., R. 99 W., and along Shoshone River between Lovell and Kane. The land ranges from gently sloping to rolling or hilly. Drainage is well developed, and the soil is well suited to irrigation. Owing to the gravelly character of the subsoil, soil of the phase would require more frequent irrigation but would be better drained than the typical soil.

About 50 per cent of the land is under cultivation, the remainder being used as grazing land for sheep and cattle. The natural vegetation is the same as that on the typical soil. On cultivated areas very good crops of beans, peas, alfalfa, and sugar beets are grown. The soil is perhaps more productive than Ralston fine sandy loam but is comparatively unimportant, owing to its small extent.

MEETEETSE SILT LOAM

The surface soil of Meeteetse silt loam to a depth of 6 or 8 inches consists of pale reddish-brown slightly calcareous mellow silt loam. In places a slight crust and mulch structure is developed over the surface. The upper part of the subsoil consists of pale reddish-brown or light reddish-brown moderately compact calcareous heavy silt loam which is firm and without apparent structure until disturbed, when it breaks up to granular structure. Beginning at a depth ranging from 9 to 11 inches and continuing to a depth ranging from 28 to 34 inches is very compact pale reddish-brown clay loam or heavy loam which is slightly cemented with lime. This material is very open and porous, owing to a great number of tubular pore spaces formed by the decay of plant roots. In some places the spaces have lost their original form and are irregular in shape. Lime-coated granules and lime accumulations give this material a speckled or mottled appearance. The lower part of the subsoil consists of pale reddish-brown moderately compact heavy loam or loam which is rather calcareous but shows no visible lime accumulations. This material is of somewhat laminated character directly over the shale or sandstone bedrock on which it rests.

Meeteetse silt loam occurs mainly in the southeastern part of the Shoshone area. A body of appreciable size is north of United States Highway No. 20 along the east boundary of the area. Several smaller bodies are south and west of this locality and bordering Oregon Coulee. Two moderately large areas lie 6 miles west of Kane.

The relief of this soil is prevailingly that of an alluvial fan. Some areas are rolling or hilly and include undifferentiated areas of residual Greybull soils. The surface of the soil is as a whole favorable to irrigation practices. Drainage is good under natural conditions, though some flat areas would probably require artificial drainage under irrigation.

Winter fat grows on the flatter areas of this soil under virgin conditions, and native grasses, rabbit brush, and sagebrush grow on the more sloping areas. A surface crust and mulch structure is present on most areas that support winter fat. None of the soil is under cultivation, though when irrigated it should prove a valuable soil in the production of all crops suited to local conditions. It lies largely within the proposed Oregon Basin division of the Shoshone project and at present (1927) is not open to settlement.

Meeteetse silt loam, gravelly subsoil phase.—The surface 6 or 8 inches of Meeteetse silt loam, gravelly subsoil phase, has a granular, mellow structure, a low organic-matter content, and is slightly calcareous. To a depth ranging from 12 to 15 inches the subsoil consists of pale reddish-brown moderately calcareous compact loam or clay loam which is mottled or speckled somewhat with lime in the lower part. The lower subsoil layer consists of pale reddish-brown gravelly loam or clay loam in which the gravel are largely of limestone origin, of medium size, and more or less coated with lime carbonate. Sandstone or shale bedrock is reached at a depth ranging from 38 to 60 inches.

Soil of this phase occurs only in the eastern part of the Shoshone area. A large body is in the northern part of T. 52 N., R. 99 W., another area is in section 24 of the same township and range, and two others are 4 miles west of Kane. In general, the land is gently sloping and fanlike, though some areas are rolling or hilly. Most of the soil is well suited to irrigation and has proved equally as productive as the typical soil. The soil drains well under irrigation and is little troubled with alkali accumulation. The natural vegetation consists of grasses, sagebrush, and rabbit brush. The soil is valued the same as the soils with which it is associated.

MEETEETSE LOAM

A 3-inch layer of light reddish-brown platy loam covered with a thin crust of very fine sandy loam in most places constitutes the topsoil of Meeteetse loam, but in many places the topsoil is 8 or more inches thick. Between depths of 3 and 11 inches the soil is compact cloddy light reddish-brown loam which is mottled more or less with white accumulated lime and contains numerous roots and root holes. The clods are thinly coated with reddish-brown colloidal material. Between depths of 11 and 35 inches light grayish-yellow very fine sandy loam occurs, in which a small amount of lime accumulation resembling mold is present. The soil in this layer forms clods which are easily crushed with the fingers. Below this layer the soil material consists of stratified alluvial-fan materials. In many places the soil color from a depth of 11 inches to a depth of several feet is red or pink instead of prevailing yellow. The soil is calcareous

throughout the entire profile. Like Meeteetse fine sandy loam, this soil occupies alluvial fans adjacent to the uplands. It is underlain by interstratified red shales and pale-gray sands, as are the other members of the series.

Natural vegetation consists of winter fat, grama, pricklypear, and some sagebrush. The soil is well suited to irrigation, provided drainage ditches are installed to take care of the excess water. In most places natural drainage is good, but there would undoubtedly be more or less trouble from alkali if irrigation were attempted without artificial drainage.

The soil is not cultivated to a great extent, but the land under cultivation is productive and is fully equal in agricultural value to Billings loam. At present it is used chiefly for alfalfa, but it would doubtless be well suited to potatoes, grains, beans, and sugar beets. No areas of this soil are near enough to the railroad to allow profitable production of sugar beets. The soil is very inextensive in the Shoshone area.

MEETEETSE CLAY LOAM

The surface soil of Meeteetse clay loam is characterized by a thin surface crust and mulch which in most places is about one-half inch thick. The crust is somewhat lighter colored than the underlying mulch material and consists of one-eighth inch of pale reddish-brown moderately calcareous clay loam. The surface of the crust is smooth and firm, and the underside is rough, consisting of loosely cemented granules of soil similar to those composing the mulch which is loose and fluffy. The mulch is underlain by firm reddish-brown clay loam which breaks up, when disturbed, to a fine granular structure. This material is low in organic matter. At a depth ranging from 7 to 10 inches the surface soil grades into extremely compact pale reddish-brown clay which continues to a depth ranging from 26 to 30 inches. This layer is characterized by lime-carbonate accumulations, which give it a speckled or mottled appearance, and by its porosity. Under a magnifying glass the material appears to be made up of a great number of small granules separated on one or more sides by small pore spaces. The granules are cemented together with lime, and clods are broken down to a fine granular structure with difficulty. Cracks and cleavage planes in this layer give a faint suggestion of coarse columnar structure. Below the zone of lime accumulation the subsoil is less compact and consists of pale reddish-brown clay loam which continues to a depth ranging from 38 inches to 10 feet, where it rests on shale or sandstone bedrock. The lower part of the subsoil is dense and does not contain visible evidence of lime accumulation. It is, however, highly calcareous.

Meeteetse clay loam is developed in a great number of small scattered areas throughout the southern and eastern parts of the Shoshone area. One of the largest bodies extends across the Meeteetse road 6 miles south of Cody. Two areas, together comprising about one-half square mile, are 2 miles southwest of Beck Lake. A number of areas, most of them including less than 60 acres each, are in the vicinity of Dry Creek and Oregon Coulee in the southeastern part of the surveyed area. Several small bodies lie both north and south of United States Highway No. 20 in the eastern part. A large

area northeast of Frannie just east of Sage Creek (east), and a small one 2 miles west of Cowley have alkali accumulations, but the one near Frannie is being reclaimed by drainage ditches.

This soil occupies the lower slopes of alluvial fans and low stream terraces and has a smooth gently sloping surface. It is well drained under natural conditions, but when irrigated is found to be in need of artificial drainage.

The natural vegetation consists largely of winter fat and sagebrush. About 10 per cent of the soil is under cultivation. Well-drained areas should prove productive under irrigation.

SHOSHONE FINE SANDY LOAM

The surface soil of Shoshone fine sandy loam consists of 8 or 10 inches of light grayish-brown or rather dull grayish-brown or brownish-gray friable fine sandy loam which is low in organic matter. The subsoil to a depth ranging from 6 to 8 feet consists of light brownish-gray or grayish-brown stratified sediments of fine sandy loam, loam, sandy loam, or gravel. The soil materials show no evidence of weathering and range from mildly to strongly calcareous throughout the profile. At a depth generally greater than 6 feet the soil rests on sandstone or shale bedrock. Along the smaller creeks the soil is lighter colored and deeper than on the flood plains of the larger streams.

This soil is rather extensive. The largest areas are along Shoshone River and its larger tributary creeks and along Big Horn River.

Shoshone fine sandy loam is a recent alluvial soil of mixed origin. It occupies positions only slightly above the normal flow of the stream which it borders, and the land in most places is somewhat gullied by stream action. Drainage is good under virgin conditions except during short intervals when the land is overflowed. Areas of this soil adjacent to higher terraces which are irrigated, however, are rendered very largely worthless, owing to seepage and alkali accumulation.

About 30 per cent of the soil is under cultivation. It is easily handled and produces good yields of wheat, oats, and alfalfa.

Along the rivers the soil supports a natural growth of cottonwoods, buffaloberries, rosebushes, and various meadow grasses. Along smaller creeks, where there is less moisture, sagebrush, rabbit brush, and winter fat abound.

Shoshone fine sandy loam, terrace phase.—The terrace phase of Shoshone fine sandy loam is essentially the same as the typical soil except that it lies about 6 or 8 feet higher than the latter, on a low terrace. The profile is identical with that of the typical soil, but the higher position of the phase makes irrigation possible without danger of seepage and alkali accumulation.

This soil occurs on the rather wide first bottoms of Shoshone River between Penrose and Byron. It is a good soil for the production of grains, alfalfa, sweetclover, and beans. Alkali-free areas are valued at somewhat higher prices than areas of the typical soil.

Shoshone fine sandy loam, poorly drained phase.—The surface 8 or 10 inch layer of Shoshone fine sandy loam, poorly drained phase, consists f dull grayish-brown or dark grayish-brown fine

sandy loam which contains a moderate amount of organic matter and is mildly calcareous. The subsoil, to a depth ranging from 6 to 9 feet, consists of dark brownish-gray or dark grayish-brown fine sandy loam, loam, or sandy loam, slightly mottled with gray and rust brown. The subsoil rests on sandstone or shale at a depth ranging from 6 to 9 feet.

This is an inextensive soil. It occurs mainly along Shoshone River, from Corbett Dam to the east boundary of the area, most of the bodies being less than 100 acres in size. Most of the soil occurs in somewhat depressed areas, and drainage, especially subdrainage, is poorly developed. The soil is poorly suited to irrigation and is more or less affected with alkali. None of it is under cultivation, nor is it regarded highly for agricultural purposes. It furnishes fair pasture for cattle.

SHOSHONE LOAM

Shoshone loam consists of dull brownish-gray or dull grayish-brown loam, in most places underlain at a depth ranging from 8 to 12 inches by dull grayish-brown or brownish-gray stratified light-textured sediments. The surface soil is low in organic matter and is of granular structure. Both surface soil and subsoil effervesce with dilute hydrochloric acid. The subsoil rests on bedrock of sandstones or shale at a depth ranging from 6 to 10 feet.

Accumulations of alkali occur rather commonly in this soil. In most places the salts are concentrated below a depth of 2 feet and in many localities are present in sufficient amounts to be toxic to crop plants. No black alkali was observed in this soil, however.

The geologic origin and method of formation of Shoshone loam are the same as those of Shoshone clay loam. This soil is composed mainly of sediments eroded from shales and sandstones occupying the more elevated parts of the area and from sediments carried out from igneous rocks of the mountains. The soil occurs in the stream bottoms of both Sage Creeks, Sulphur Creek, Iron Creek, Buck Creek, and Dry Creek (west) and its tributaries. The largest areas are along Shoshone River between Lovell and Kane.

Drainage of this soil is somewhat better than that of Shoshone clay loam, but the land is likely to become water-logged and more or less affected with alkali in case the surrounding soils are put under irrigation.

The natural vegetation along the smaller creeks is largely sage, but on areas affected with alkali the common greasewood and other alkali-tolerant plants hold sway. Along the rivers the vegetation consists of cottonwoods, rosebushes, buffaloberries, and various grasses.

This soil is used chiefly for alfalfa and grain crops. No fertilizers are used, but barnyard manure is applied.

This soil would be improved by crop rotation and the growing of green-manure crops. Danger of seepage incident to the expansion of irirgation limits the value of the land for future development.

SHOSHONE CLAY LOAM

The surface soil of Shoshone clay loam is dull brownish-gray or very dark gray clay loam. It is underlain at a depth ranging from

8 to 12 inches by dull grayish-brown or brownish-gray stratified sediments ranging in texture from fine sand to silty clay loam or clay loam. Gravel occurs in most of the soil at a depth ranging from 3 to 5 feet. The surface soil is low in organic matter and is of granular structure. The subsoil is slightly compact though without evidence of weathering. Both surface soil and subsoil are uniformly calcareous. The subsoil rests on bedrock of sandstone or shale at a depth ranging from 4 to 8 feet.

Alkali salts occur rather commonly in this soil, the salts being concentrated below a depth of 2 feet as a rule. There is, however, no evidence of black alkali. In the poorly drained areas the soil generally contains sufficient alkali to prevent or greatly hinder the growth of farm crops.

Shoshone clay loam is a recent alluvial soil occurring along the stream courses of Cottonwood Creek, Sage Creek (west), Sage Creek (east), and along Shoshone River from Lovell to Kane. The land is gently sloping, and the soil is easily brought under irrigation.

The soil material has weathered largely from sandstones and shales, and has been subsequently transported and deposited along the stream courses. Drainage ranges from good to poor.

The natural vegetation on the better-drained areas consists of a luxuriant growth of sage, but in the areas of alkali accumulation sage gives way to winter fat and greasewood. Along Shoshone River are some cottonwoods and meadow grasses. This soil is of minor importance in the agriculture of the area, as it is not extensive and only a small proportion of it is utilized because of the difficulty of cultivation and the danger of its becoming water-logged and affected with alkali.

This soil is used chiefly for the production of grains and sugar beets, and areas not affected with alkali are fairly productive. No fertilizers or crop-rotation systems are used.

The soil would no doubt be greatly improved by the incorporation of organic matter and by providing better drainage. Expansion of the irrigated part of the Shoshone area will probably result in most of this soil becoming water-logged.

PIERRE LOAM

The topmost half-inch of Pierre loam consists of a crust of pale yellowish-gray strongly calcareous very fine sandy loam which is full of very fine round holes. Below this to a depth of 2½ inches is pale grayish-brown calcareous loam in the form of a very fine granular mulch. This layer, in turn, is underlain to a depth of 8 inches by grayish-brown calcareous heavy compact cloddy loam which is pierced by many roots. Between depths of 8 and 18 inches is dark olive-drab loam with threads of lime and gypsum accumulation following old root channels. This layer contains many roots, and the material breaks into small irregular clods. Below 18 inches and extending to a depth of 24 or more inches is dark-gray, nearly black when moist, silty clay loam which consists of weathered shale. No lime occurs in this layer.

The soil is entirely too shallow to be of agricultural value, and alkali invariably accumulates when the land is irrigated. Many areas of this soil were put under the ditch near Frannie and pro-

duced fair crops for a short time, but most of the soil has become so impregnated with alkali salts that it is now worthless.

Large areas of this soil are northwest of Byron, northeast of Cowley, and south and east of Frannie.

Pierre loam is partly covered by a growth of winter fat which affords good winter pasture for sheep, and the land is used for that purpose.

PIERRE CLAY LOAM

The topmost one-fourth inch of Pierre clay loam is a crust of pale yellowish-gray calcareous loam filled with very fine spherical pores. Below this and continuing to a depth of 4 inches is dark-gray cloddy clay loam mottled with reddish brown and containing a few crystals of gypsum. When wet the soil is much darker colored and very plastic. This layer is underlain to a depth of 16 inches by dark-gray rotten shale mottled with reddish-brown iron stains and occasional clumps of gypsum crystals. The material breaks into medium-sized angular grains. From a depth of 16 inches and extending to an undetermined depth the material is the same as that in the layer above, except that there are fewer iron stains and the shale is less rotten.

The principal vegetation on this soil is winter fat. Some attempts have been made to cultivate the land near Frannie and Deaver, but results have been discouraging in practically every case, as alkali is almost sure to accumulate and there is no practical way to drain off the excess water and wash out the alkali. In its virgin condition the soil affords fair winter pasture for sheep.

ROUGH BROKEN AND STONY LAND

Rough broken and stony land includes the steep gravelly slopes between the flatter tops of the stream terraces and also the outcropping areas of sandstone and shales which are too steep or too stony to be irrigated. These areas support a sparse growth of sagebrush, rabbit brush, winter fat, and grasses, and they are useful only for grazing, except many very small spots of included soils which are suitable for raising crops but are too small to be differentiated on the map.

Areas of rough broken and stony land are very widely distributed throughout the Shoshone area. Especially large areas occur around the margins of the surveyed area where the land slopes rapidly upward into the foothills and mountains. Large fingerlike ridges extend out from Polecat Bench and other high terraces into the flatter lands of the lower terraces. Strips of this rough land also occur along the borders of the larger creeks which are tributary to Shoshone and Big Horn Rivers.

DUNE SAND

Dune sand includes areas of pale yellowish-gray fine sand or loamy fine sand which has been blown up in hillocky dunes and overgrown with rabbit brush and greasewood in places. In some places the land is leveled and farmed, but it is of very little value both because it will not hold water and because it is easily transported by the wind.

Dune sand occurs along the river and creek bottoms and on alluvial fans associated with soils of the Billings series. The principal areas are along the road between Byron and Penrose, north of Shoshone River.

RIVER WASH

River wash consists of a mixture of cobblestones, gravel, and sands occurring in areas which are overflowed at periods of high water. It is mapped along Shoshone and Big Horn Rivers.

This material is of unfavorable physical character and supports little or no vegetation except a few weeds and shrubs, and the land is of no agricultural importance.

SOILS AND THEIR INTERPRETATION

The following general discussion of the soils of the Big Horn Basin applies to the soils mapped in the Shoshone and Basin areas.[3] A few of the soils discussed occur outside the areas mapped, but they are of sufficient scientific interest to be included in this report.

Big Horn Basin is an intermountain lowland lying between the main ranges of the Rocky Mountains on the west and the Big Horn Mountains on the east. It is further hemmend in on the south by the Owl Creek Range and on the north by the Pryor Mountains. Big Horn River enters the basin through a gorge in the Owl Creek Range and leaves by a gorge lying between the Big Horn and Pryor Mountains. This river has several large tributaries, the principal ones being Greybull and Shoshone Rivers. The land surface is dominated by a series of great alluvial terraces with surface or deeper deposits of gravel of various dark-colored igneous rocks, and these are underlain by sandstones and shales of various geologic periods. In places the soils are derived from local alluvial-fan materials, having their source in these shales and sandstones, instead of from the alluvial terrace materials transported to the area from greater distances. This is especially true in the region adjacent to the McCollough Mountains, which are a series of bad-land mountains in the north-central part of the basin. Large areas of residual soils, formed by weathering of the shales and sandstones in place, occur in the south-central part of the basin on both sides of Big Horn River.

The climate of the Big Horn Basin is that of a cool, temperate desert, with an average rainfall, over the region as a whole, of about 6.5 inches. The mean annual temperature is about 44° F., with extremes of 111° and −51° having been officially reported. Outside the basin, in every direction, the precipitation increases and the mean annual temperature decreases. The altitude of the basin ranges from about 3,800 feet to more than 5,000 feet above sea level.

The distribution of vegetation seems to vary somewhat with the soils and somewhat with the slight variations in climate which obtain in the Big Horn Basin. However, in general the vegetation is largely of the same type throughout the basin. The principal upland plants are sagebrush (*Artemisia tridentata*),[4] winter fat (*Eurotia lanata*), greasewood (*Sarcobatus vermiculatus*), shadscale (*Atriplex confertifolia*), rabbit brush (*Chrysothamnus* sp.), grama (*Bouteloua oligostachya*), and needle grass (*Stipa comata*). Of the smaller flowering plants various Pentstemons as Indian paint-

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[3] See footnote 1, p. 1.

[4] Plants were identified in the field and the names can be considered only approximately correct.

brush (*Castilleja* sp.), evening primrose (*Onagraceae* sp.), and some larkspur (Delphinium), along the edges of the mountains, are the most common. Rabbit brush is common on the very sandy soils, sagebrush grows largely on soils with gravelly or sandy subsoils, winter fat on soils with slight amounts of alkali salts, and greasewood on moist soils which generally contain some soluble salts. Shadscale grows on soils in slight depressions which are fairly well drained but are underlain by excessive accumulations of lime and gypsum. Grama and needle grass are commonly found on the same kinds of soil as those supporting sagebrush, and in some places they grow in association with sagebrush. Most of the smaller flowering plants also occur in association with sagebrush. Pricklypear is commonly associated with grama and needle grass on sandy soils underlain with gravel. The vegetation along the rivers and creeks differs greatly from that just described, because the soil in such places is moister than in most of the basin.

As far as may be determined, the soils of the Big Horn Basin have never supported a forest growth since the land surface reached its present general configuration. It has never supported a sufficiently heavy growth of grasses for organic matter to accumulate in quantity. Consequently the soils are all very light colored on the surface. Toward the foothills in the western part of the Shoshone area the grass vegetation increases and there is a corresponding darkening of the surface soil. Just outside the boundary of the area in the foothills of Heart Mountain the soils become very dark colored and have a decided tendency to granulation in the A horizon, and the angular grains are rather thickly covered with dark-colored organic material. In the eastern part of the Basin area the soils retain their desert characteristics, and there is no noticeable change in the soil in this region until a height of 1,000 feet is reached, where conditions are rather similar to those at the foot of Heart Mountain. This difference seems to be due to the fact that summer storms drifting almost daily from the western mountains keep the soils rather moist for a large part of each summer, whereas on the eastern side of the area the precipitation does not begin until the eastward-blowing winds have been cooled on the higher slopes.

Observed from almost any hilltop in the Big Horn Basin, the prevailing color of the soil appears pale brownish gray. On the few days that the soils are moist on the surface this color becomes browner and slightly darker. Where erosion has exposed the underlying horizons various colors are noticeable, but the predominating color is very light brown. In some places the red colors of parent red shales persist more or less in the soil, and in others the dark-gray shales lend their color to the soils.

For convenience in describing their broad characteristics the soils of the Big Horn Basin are classified as follows:

Maturely weathered soils, including soils of the Ralston, Gilcrest, and Worland series (in Basin area only); moderately weathered soils, including the Chipeta soils and the gravelly subsoil phases of the Meeteetse and Billings soils; slightly weathered soils, including normal types of the Meeteetse and Billings series and soils of

the Moffat series (in Basin area only); unweathered soils, including soils of the Shoshone series; and shallow soils developed in place on impervious shales and sandstones, including soils of the Pierre series and of the Greybull series (in Basin area only).

Detailed descriptions will be given of the mature soils of the Big Horn Basin, and less detailed descriptions of those that have not reached such an advanced stage in weathering. The fine sandy loams of the Ralston, Gilcrest, and Worland series are representative not only of the maturely weathered soils of the region but also of the prevailing soil texture.

The sample of Ralston fine sandy loam herewith described was taken from an uncultivated spot on a high bench, or terrace, bordering Dry Creek (east) and known as Emblem Bench. The description will be taken up by horizons.

Horizon A, from the surface to a depth of one-eighth inch, is a crust of very pale brownish-gray slightly calcareous fine sandy loam. From a depth of one-eighth inch to a depth of 1½ inches is a mulch of very pale brownish-gray loose loamy fine sand of single-grain structure, which is slightly calcareous. On the loams and clay loams of this region the crust is slightly thicker than in this sample and is filled with small spherical pores, or vesicles, from one-sixteenth to one thirty-second of an inch in diameter. By actual experiment these were found to be made by imprisoned air which takes the form of small spheres when the soil becomes puddled on the surface during the beating summer rains. On these heavier types of soil the mulch is in the form of very fine angular grains which make a loose mulch when dry. Between depths of 1½ and 5 inches is light yellowish-brown laminated fine sandy loam containing many plant roots. This material tends to break up into thin flakes, and this tendency is much more pronounced in the heavier soils. This layer is strongly calcareous.

Horizon B, from a depth of 5 to a depth of 12 inches, is light yellowish-brown slightly compact fine sandy loam which breaks into irregular friable clods. It contains many roots and root cavities, and the dead roots and rootlets are incased in white lime tubes resembling mold mycelia. The soil material breaks into faintly defined columns and is strongly calcareous. Between depths of 12 and 22 inches is grayish-white or yellowish-white loam with irregular vertical streamers of yellowish-brown lighter-textured materials following the larger masses of roots. This layer contains more lime than any other layer in the profile. Between depths of 22 and 32 inches is a layer which might be considered as belonging to the lower B or upper C horizon, according to the viewpoint. The main mass of material is C material, but there is some concentration of lime. The layer consists of dark-colored igneous alluvial gravel and sands, with the interstices filled with grayish-white or yellowish-white lime accumulation. Few plant roots extend below this depth. In many places this layer contains some white or pink gypsum deposits. This is more common in the heavier types of soil, however.

In horizon C, from 32 inches to a depth of several feet, the material consists of dark-colored igneous alluvial gravel and sands. On the higher terraces, such as the Polecat Bench in the Shoshone

area, the gravel in the upper part of the layer are rather well weathered, and when cracked with a hammer are found to have a thin film of white lime along the joints. On the lower terraces the gravel and cobblestones are hard and unweathered.

Where the Ralston soils are exposed in road cuts or along steep declivities along the edges of the terraces they stand in a vertical plane with faintly defined columnar structure. The alluvial gravel lie, at a depth ranging from 4 feet to as much as 20 feet, on sandstones and shales which have been unequally eroded.

The natural vegetation on the Ralston soils is mainly sagebrush, grama, rabbit brush, pricklypear, and winter fat. The first three are common on the lighter-textured soils, and winter fat is common on the heavier soils.

The Gilcrest soils resemble the Ralston soils in surficial characteristics and differ from them chiefly in having darker A horizons which contain little or no free lime carbonate. They support a larger proportion of native grasses and receive a somewhat higher rainfall than the Ralston soils.

Worland fine sandy loam, which was identified and mapped only in the adjoining Basin area, resembles the Ralston soil very closely in every respect except that it has entirely different parent material and the color of the upper part of the B horizon is reddish brown instead of light yellowish brown as in Ralston fine sandy loam. This difference in color is probably due to the fact that the Worland soil is derived from dark-red shales interstratified with pale-gray fine sands. The lime accumulation extends into the rotten upper layers of sandstone in Worland fine sandy loam in a way similar to the extension of this material into the alluvial gravel of the Ralston soil. Vegetation on this soil is the same as that on Ralston fine sandy loam.

In these maturely weathered soils several striking points of interest may be noted. First among these is that although, as a rule, the parent materials of these soils are noncalcareous rocks, the soils are calcareous from the surface or near it well into the parent material. This is because the carbon dioxide from the air and from the decomposition of organic matter reacts with the silicates and other compounds of calcium and magnesium to form carbonates. This process is active in all soils, but only in those which occur where the rainfall is light do the carbonates remain. Although there is some lime in the A horizon, the greater part of it has been translocated by the process of leaching to the B horizon, where it has accumulated in large quantities. In a somewhat similar manner gypsum has accumulated in the lower part of the B horizon and in the upper part of the C horizon. Where the soil contains appreciable quantities of soluble salts, the salts are more concentrated below the gypsum. Another very noticeable characteristic is that the soils at the immediate surface have very little real color, being nearly neutral gray. The lower part of the A and upper part of the B horizons, on the other hand, generally show a decided yellow, brown, or red tint according, apparently, to the color of the parent materials. There is invariably a layer of moderate compaction, which is generally the most highly colored layer in the profile, just above the layer of maximum lime accumulation, indicating a translocation of fine materials from the

upper layers. In the Worland soils the material of this layer is thinly coated with reddish-brown colloidal material. This tendency is noticeable to less degree in the Ralston soils.

The soils of the Chipeta series are recognized as moderately weathered soils. They show the same general type of profile as the Ralston and Worland soils but have not had time to develop quite so far, and their lime horizon is in most places considerably thinner. The gravelly subsoil phases of the Billings and Meeteetse soils also belong to the group of moderately weathered soils.

Soils which are in the process of formation on the broad alluvial fans of the area have been classified as slightly weathered soils. They include the various members of the Meeteetse, Billings, and Moffat series, with the exception of the gravelly subsoil phases of the Meeteetse and Billings soils. Soils of these series are essentially the same in every respect except color. The differences in color are due primarily to the differences in color of the parent upland materials from which the alluvial fans were built up. The Meeteetse soil materials are derived from red shales, the Billings, from gray shales and sandstones; and the Moffat, from brick-red sandstones. All these soils have the prevailing pale-gray crust and mulch, are laminated in the upper layers, and most of them have a layer of very slight compaction. In places they all show a very slight accumulation of lime under the layer of compaction, but in many places this is not noticeable to the naked eye. They are mainly stratified soil materials, and in many places where the soil is exposed on creek banks or road cuts old soil levels can be discerned. All these soils are strongly calcareous throughout, and all stand in vertical columns where exposed. Detailed descriptions of these soils are given in the section on Soil Series and Types.

The only soils included in the unweathered group are those of the Shoshone series. They consist of recently deposited soil material and in the scientific sense are not true soils. Detailed descriptions are given under Soil Series and Types.

The soils of the Greybull and Pierre series are grouped together because they are shallow, immature soils of a residual character. Their shallowness and immaturity are due to the impervious character of the parent rocks rather than to erosion or any other cause. The Greybull soils, which are red soils derived by weathering in place of red shales and sandstones, were differentiated only in the adjoining Basin area, but it is now recognized that some undifferentiated areas of these soils are included with the Meeteetse soils of the Shoshone area, particularly in the Oregon Basin and vicinity. The Pierre and the Greybull soils show practically the same sequence of layers as the Ralston and Worland soils, the chief difference being that in the Pierre and Greybull soils the layers are exceedingly thin. A detailed profile description of Pierre loam follows:

Horizon A, from the surface to a depth of one-half inch, is a crust of very pale yellowish-gray very fine sandy loam which is full of spherical vesicles and is calcareous, and between depths of one-half inch and 2½ inches is a mulch of dark yellowish-brown fine granular loam which is calcareous and somewhat laminated.

Horizon B, between depths of 2½ and 3½ inches, is dark grayish-brown or yellowish-brown loam containing some spots of accumu-

lated lime. The material in this layer is highly effervescent with dilute hydrochloric acid, and a little gypsum and a few fragments of shale occur. Between depths of 3½ and 10 inches is dark-gray or dark olive-drab mottled silty clay loam filled with fine white and yellow gypsum crystals. The material of this layer does not effervesce noticeably with acid, and roots are more numerous than in any other layer.

Horizon C, from a depth of 10 inches and extending to a depth of 36 or more inches, is very dark slate-gray rotten shale which becomes lighter in color when crushed. This material has a silty loam or clay texture. A few gypsum crystals occur in the upper part of the layer and some rust-brown iron stains are noticeable along the cleavage planes. This layer contains no lime that can be detected by acid. It generally contains from 0.3 to 0.5 per cent of soluble salts.

It will be noted from the foregoing description that the solum is fairly complete as expressed in horizons but that it extends to a depth of only 10 inches. Horizons in the Greybull soils are less distinct, but the solum averages thicker.

On the slopes of the Big Horn Mountains it is possible to trace soil differences which correspond roughly with the soil differences to be observed in progressing from the Big Horn Basin, Wyo., to northern Minnesota.[5] Up the western slopes of the Big Horn Mountains, an accumulation of organic matter in the A horizon begins to be noticeable about 1,000 feet above the general level of the basin. This soil corresponds to the light-brown soils of the Great Plains. Somewhat higher the soil becomes darker brown, until at an altitude of about 7,500 feet a soil resembling the black earths occurs. A short distance above this the soil loses its layer of lime accumulation and becomes acid. On the grass and sagebrush lands this soil resembles the black prairie soils except that it is much shallower. The soils covered by lodge-pole pine, spruce, and fir forests resemble those in the forested region of northern Minnesota. They are strongly acid, and the upper layers are highly leached and show very little accumulation of organic material. In general, the parent materials on the west slope of the Big Horn Mountains are similar to the parent materials in the basin, so it may be reasonably assumed that the soil differences in this region are due fundamentally to differences in climate and vegetation, similar to those which are known to exist at progressive altitudes on the mountains.

IRRIGATION, DRAINAGE, AND ALKALI

In the Shoshone area, the rainfall is light and irrigation must be depended on for the successful maturity of all cultivated crops. Since the first settlement of white men in this area irrigation has been practiced to some extent in the development of home gardens, in the production of wheat, or to improve natural meadows bordering stream ways. The early systems were necessarily crude, water being diverted by wing dams formed by laying a few rocks in the stream channel and carrying the water in shallow ditches to the fields to

[5] THORP, J. THE EFFECTS OF VEGETATION AND CLIMATE UPON SOIL PROFILES IN NORTHERN AND NORTHWESTERN WYOMING. Soil Sci. 32: 283–301. 1931.

be irrigated. Early irrigation was confined entirely to the stream bottoms or to the low-lying terrace lands adjoining.

It was not until 1900 that the practice of irrigation was attempted on a large scale in this area. In that year water was supplied to lands in the vicinity of Cody by a ditch taking its water from South Fork Shoshone River. The project was successful and is well established at the present time. Approximately 20,000 acres are now irrigated in the vicinity of Cody.

In 1905 the United States Reclamation Service (now the Bureau of Reclamation) began the construction of a dam in Shoshone Canyon to impound water a deregulate the flow of Shoshone River for use in the irrigation of lands extending from the vicinity of Cody to the northeast as far as the Wyoming-Montana State line.

In 1908 water was diverted from the River at Corbett to irrigate the Garland division of the Shoshone project. All of this division is now under irrigation. Proposed extensions of this project include about 90,000 acres in the Oregon Basin division, a part of which lies in the Shoshone area, taking its water directly from the Shoshone Reservoir, and about 38,000 acres in the Heart Mountain division, which lies within the Shoshone area.

Water is conveyed to the fields in open ditches and distributed by means of small lateral ditches. By means of a canvas temporarily placed in the lateral ditches the water is diverted at intervals and allowed to run over the fields. Grainfields are irrigated as the season and soil demand, generally three or four times a season. Alfalfa is irrigated at intervals of about 20 days throughout the growing season. The soils with gravelly subsoils at slight depths require more frequent irrigation and use appreciably more water than those with less porous subsoils. In general the duty of water runs from 2 to 2.7 acre-feet a season.

Drainage problems have arisen, as the shales underlying this region are comparatively high in soluble salts, and where they closely approach the surface, accumulation of alkali salts may occur. The problem of drainage must be considered sooner or later in all large irrigated areas. This problem is just as important as that of getting water to the land, and it is frequently a more difficult one to solve. There is no large body of soil in the Shoshone area that does not need a drainage system to supplement irrigation. Any land which is placed under the ditch in the future should also be supplied with adequate drainage facilities to insure the settlers against the menace of alkali accumulation in the soils.

In general the soils of the Ralston, Gilcrest, and Billings series are well suited to irrigation practices and can be put under cultivation without great expense in the preparation of the land for water. They are well drained and should give little trouble from accumulation of alkali except in local areas where underground dikes formed by the unequal erosion of the underlying shales prevent the free movement of subsurface waters. They are now comparatively free of alkali. They absorb moisture readily, but in the shallower members of the group much water is lost through percolation into the loose gravelly substratum. These soils should prove productive.

The sandstones and shales underlying the Chipeta, Pierre, and some of the Meeteetse soils are heavily impregnated with alkali salts

and, though the surface soils are comparatively free of alkali under virgin conditions, the subsoils in many places contain an appreciable amount. Chipeta loam, shallow phase, would be of little or no value under cultivation because of its shallow character and the prevalence of alkali in the soil material and underlying bedrock. Chipeta clay loam and Meeteetse clay loam under irrigation would be more difficult to handle than the lighter-textured loams and sandy loams which comprise the remainder of the group.

Ralston loam, poorly drained phase, Shoshone fine sandy loam, poorly drained phase, and parts of Shoshone loam and Shoshone clay loam would be subject to seepage under extensive irrigation of the adjacent lands, and these soils have little potential value for agriculture unless they are provided with a system of artificial drains. In most places this can not be effectively done without prohibitive cost.

The soils suitable for agricultural development may be classified with respect to surface slope into three general groups as follows: Flat to gently sloping, moderately sloping, and steeply sloping. The gently sloping areas require little work to prepare them for irrigation, and irrigation water can be distributed over the soils without danger of washing or erosion. Various systems of applying water to the soil may be practiced with success on these soils. Moderately sloping areas require more careful use of water to prevent erosion. Without great expenditure for leveling they are limited in the systems by which water may be applied to the soil. Areas with this slope drain well, however, and in general they are well suited to irrigation and cultural practices. On the steeply sloping areas methods of applying water to the soil are restricted, and unless great care is used the steeper areas will erode badly. In general, it would require much labor and expense to level such areas for irrigation.

Samples of soils were collected in various parts of the area, and the percentage of alkali salts in the air-dried soil was determined. Samples were taken wherever alkali accumulation was indicated and also at frequent intervals in other parts of the area where no evidence of alkali was apparent. In the western part of the surveyed area the location at which samples were collected is indicated on the accompanying soil map by a dot, and the average percentage of alkali in the air-dry soil to a depth of 40 or more inches or to bedrock is indicated by a decimal, for example 0.67. In the eastern part of the area, the salt concentration is indicated in the form of a fractional number, as $\frac{0.29}{0.56}$, the upper figure, denoting the alkali concentration in the surface soil to a depth of 1 foot, and the lower figure, the average concentration to a depth of 3 feet or to bedrock. Samples were taken of each individual foot section and separate determinations made of each sample. The average for the total soil section was then computed.

In general, the concentration of alkali salts in various parts of the area is low under virgin conditions. However, under irrigation in areas of poor subdrainage, accumulation of the alkali salts in the surface soil may be anticipated. In practically all samples taken of soils of the Chipeta, Pierre, and Meeteetse series the soil material directly above the underlying shale and sandstone contains a large

amount of salts. Alkali determinations of samples of the shale material generally showed the presence of more than 1 per cent of salts. Under irrigation the shales and sandstones give up their soluble salts very readily, and unless the soils have good subdrainage the alkali becomes concentrated in the surface soil, preventing, or at least greatly hindering, crop growth. Owing to the large amount of alkali salts in the shales and sandstones, areas of the more shallow soils are almost sure to be rendered useless for crop production under irrigation.

An area with a rather high average alkali accumulation occurs in the Oregon Basin, and a rather large area having a moderate concentration is 3 miles east of the basin. The soils bordering the drainage courses in the southeastern, central, and northeastern parts of the area range from low to moderately high in alkali concentration. Several small areas of relatively high concentration are from 2 to 5 miles southeast of Cody and to the southwest in the vicinity of the Irma Flats. Some of the largest areas of alkali-affected soils in the surveyed area occur near Frannie, near Lovell, and at Corbett. The salt concentration in the area near Corbett is low, however. A number of small areas, embracing from 10 to 20 acres, which contain alkali accumulations, occur at various other places in the surveyed area. The salts present in the alkali accumulations consist largely of sodium chloride and sodium sulphate. No carbonate, or black alkali, was observed.

The concentration of the alkali salts differs greatly within comparatively short distances. In general, the concentration is least on the higher, better-drained soils and in soils of light texture. The variations in salt content are difficult if not impossible to map accurately in soils occurring under virgin conditions. In the Shoshone area, it has, therefore, been deemed advisable to make but one separation, the alkali-affected areas being differentiated from the alkali-free areas. Soils with a concentration of less than 0.2 per cent are considered free of injurious amounts of alkali from the viewpoint of crop production. The areas containing the higher concentrations of alkali salts are indicated on the soil map by the letter "A" in red and are inclosed by red lines. The concentration in various parts of the area is shown by fractions as already explained.

The biggest problem confronting the irrigator is to control the vertical distribution of the alkali salts in the soil section. A soil with a rather high average salt concentration but comparatively free of alkali in the surface soil can be made to produce much better crops than one with the same average concentration of alkali in the soil profile but having the point of highest accumulation localized in the surface soil. In order to control the distribution of alkali salts in the soil, drainage must be good. With fair or good drainage most crops grown in this region can be produced, without any serious evidence of injury, on soils with an alkali concentration ranging from 0.2 to 0.4 per cent. The same concentration on poorly drained soils will in many places entirely prohibit the growing of crop plants. With equal concentrations of alkali and similar drainage conditions crops can be more successfully grown on heavy-textured soils than

on light-textured soils because the water-holding capacity of the heavy-textured soils is greater and consequently dilution of the soil solution is greater. Puddling effects, or deflocculation, of clay are greater on heavier soils also, making them hard to work.

When once established, alfalfa can be grown on soils having a comparatively high alkali concentration. However, this plant, like all other crop plants, is most sensitive to alkali injury in the seedling stage, and care must be exercised to keep the alkali salts below the feeding zone of the young roots. Beans and potatoes are susceptible to injury from low concentrations of alkali. Of the commonly grown cereals, barley is the most tolerant to alkali and is rarely injured to an appreciable extent by concentrations ranging from 0.4 to 0.6 per cent of salts where drainage is well developed. Wheat and oats are only slightly less tolerant than barley. Sugar beets can be grown on soils with concentrations similar to those on which barley is grown, and corn is somewhat less resistant to alkali injury than barley.

The reclamation of alkali lands is difficult and expensive, and the greatest care should be exercised to prevent alkali accumulation. Providing drainage, supplying organic matter to the soil, and the careful use of water are the principal points to be observed in preventing alkali accumulation. After a soil has become badly affected with alkali, there is no feasible or permanent system of reclamation that does not include drainage. With good drainage, the flushing of the soil, the incorporation of organic matter, and good cultural practices will do much to correct alkali conditions. When a soil becomes deflocculated reclamation becomes increasingly difficult, owing to the slowness with which water penetrates the soil. The addition of gypsum or flowers of sulphur will improve the physical condition of many deflocculated soils. The addition of organic matter is also very beneficial.

SUMMARY

The Shoshone area includes the central and northeastern parts of Park and the northern part of Big Horn Counties, in northwestern Wyoming. The area embraces the developed lands around the town of Cody, a part of the proposed Oregon Basin division of the Shoshone project of the United States Bureau of Reclamation, and all the remainder of that project. It includes in addition all the irrigable and irrigated lands bordering Shoshone River beyond the Shoshone project. The area embraces 886 square miles, or 567,040 acres.

The area is a part of the Big Horn Basin which lies between the Rocky Mountains on the west and the Big Horn Mountains on the east. The chief physiographic features consist of the numerous river terraces and alluvial fans bordering Shoshone River and the rolling or eroded plains underlain by shale and sandstone deposits bordering the river terraces.

Elevations in the Shoshone area range from about 3,700 to 5,000 feet above sea level. Drainage is largely to the northeast into Shoshone and Big Horn Rivers, and, in the southeastern part of the area, it is to the east into Dry Creek and its tributaries. The regional drainage of the area is well developed.

The Shoshone area is sparsely populated except those parts where irrigation has been developed. Here the land is divided into tracts ranging from 40 to 120 acres in size, and one or more families live on each unit. Cody, Powell, and Lovell are the principal towns.

The Cody-Frannie branch of the Chicago, Burlington & Quincy Railroad, and the Denver, Black Hills, and Billings division of that railroad furnish transportation, and several well-improved roads including the Yellowstone Highway (United States Highway No. 20), pass through the area.

Some wheat and large quantities of potatoes, beans, peas, sugar beets, honey, and poultry are shipped to outside markets, and other agricultural products of the area are consumed locally.

The climate of the area is arid. The summers are warm, with occasional days of high temperature. The fall and spring months are mild, but the winters are cold, with many days of subzero temperatures. The mean annual rainfall ranges from 8.68 to 5.44 inches, according to locality. The average frost-free season is 114 days at Cody and 116 days at Lovell.

The grazing of sheep and cattle on the open range and the production of alfalfa and grains for supplemental winter feeding are the principal industries near Cody. Farther down Shoshone River cash crops occupy a very important place. No dry farming is attempted, the production of all crops being dependent on irrigation. The production of poultry and poultry products is increasing, and large numbers of birds are shipped yearly. The dairy industry has made a good start but could be further extended.

Farm buildings are serviceable, and farm machinery is modern and usually sufficient for the farmers' needs. Labor is plentiful and of good quality.

The soils of the Shoshone area have weathered under arid conditions. Bordering Shoshone River the soils are derived from alluvial terrace deposits of mixed origin. The soil materials occupying the plains adjacent to the river terraces have been transported to some extent but include more soil material derived from the weathering in place of the shales and sandstones which underlie the region.

According to the degree of weathering and character of profile the arable soils of the area have been classified into five groups as follows: Maturely weathered soils, moderately weathered soils, slightly weathered soils, unweathered soils, and shallow soils. In addition to these, three types of nonagricultural miscellaneous materials, including rough broken and stony land, dune sand, and river wash, have been mapped. In the groups of weathered soils, differences in color, lime content, character of subsoil and substratum, and other chemical and physical properties have given rise to five soil series, the Ralston, Gilcrest, Chipeta, Meeteetse, and Billings. The unweathered recent alluvial soils are classified in the Shoshone series.

Of the weathered soils those of the Ralston and the Gilcrest series, occupying the stream terraces, are the most maturely developed.

The Chipeta soils, which are dominantly formed by weathering in place of the shale and sandstone rocks, together with surficial alluvial overwash, have similar profiles to the Ralston and Gilcrest soils but are less maturely developed.

The soils of the Meeteetse and the Billings series are developed from slightly weathered alluvial-fan accumulations having their source mainly in shale and sandstone rocks.

The Pierre soils are shallow soils developed by weathering of the dark-colored shales in place. They are for the most part poorly adapted to farming, owing to shallowness and to their content of alkali salts. They are difficult to drain.

The Shoshone soils are inextensive. They occupy the river flood plains and low terraces adjoining stream courses. Under extensive irrigation a large proportion of these soils is rendered valueless, owing to poor drainage and resultant alkali accumulation.

Under irrigation the lighter-textured soils are used in the production of beans and potatoes. The heavier soils are recognized as being best adapted to sugar beets, alfalfa, and small grains. Potatoes also do well on the heavier soils of the Ralston and the Gilcrest series.

Irrigation was first attempted on a large scale about 1900. In that year a ditch taking water from South Fork Shoshone River was constructed to irrigate about 15,000 acres in the vicinity of Cody. In 1908 the first unit of the Shoshone project was put under irrigation, all of which unit is included in the Shoshone area. Water is conveyed to the fields in open ditches and distributed by means of small lateral ditches. An average of about 2.33 acre-feet of water a season is used.

Concentrations of alkali salts are in general low in virgin areas, but conditions of subdrainage favor rapid accumulation of salts in injurious amounts under irrigation unless adequate drainage is provided. Successful reclamation of alkali lands must be accomplished through drainage.

O

[PUBLIC RESOLUTION—No. 9]

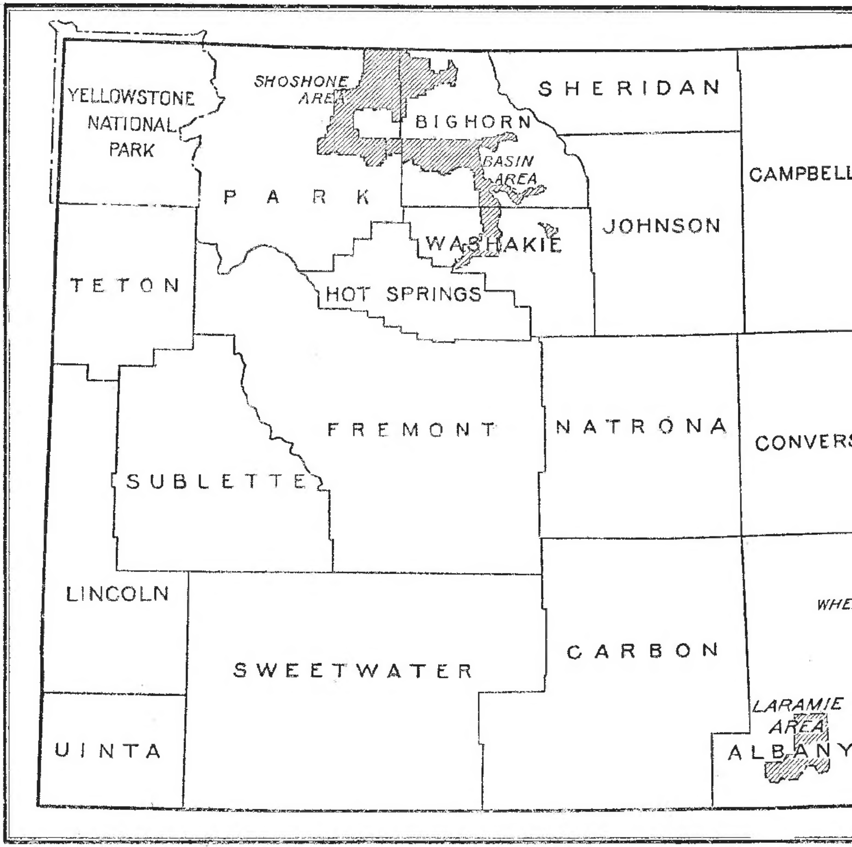
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Wyoming, shown by shading

U. S. GOVERNMENT PRINTING OFFICE: 1932

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CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP
SHOSHONE AREA
WYOMING

UNIVERSITY OF WYOMING
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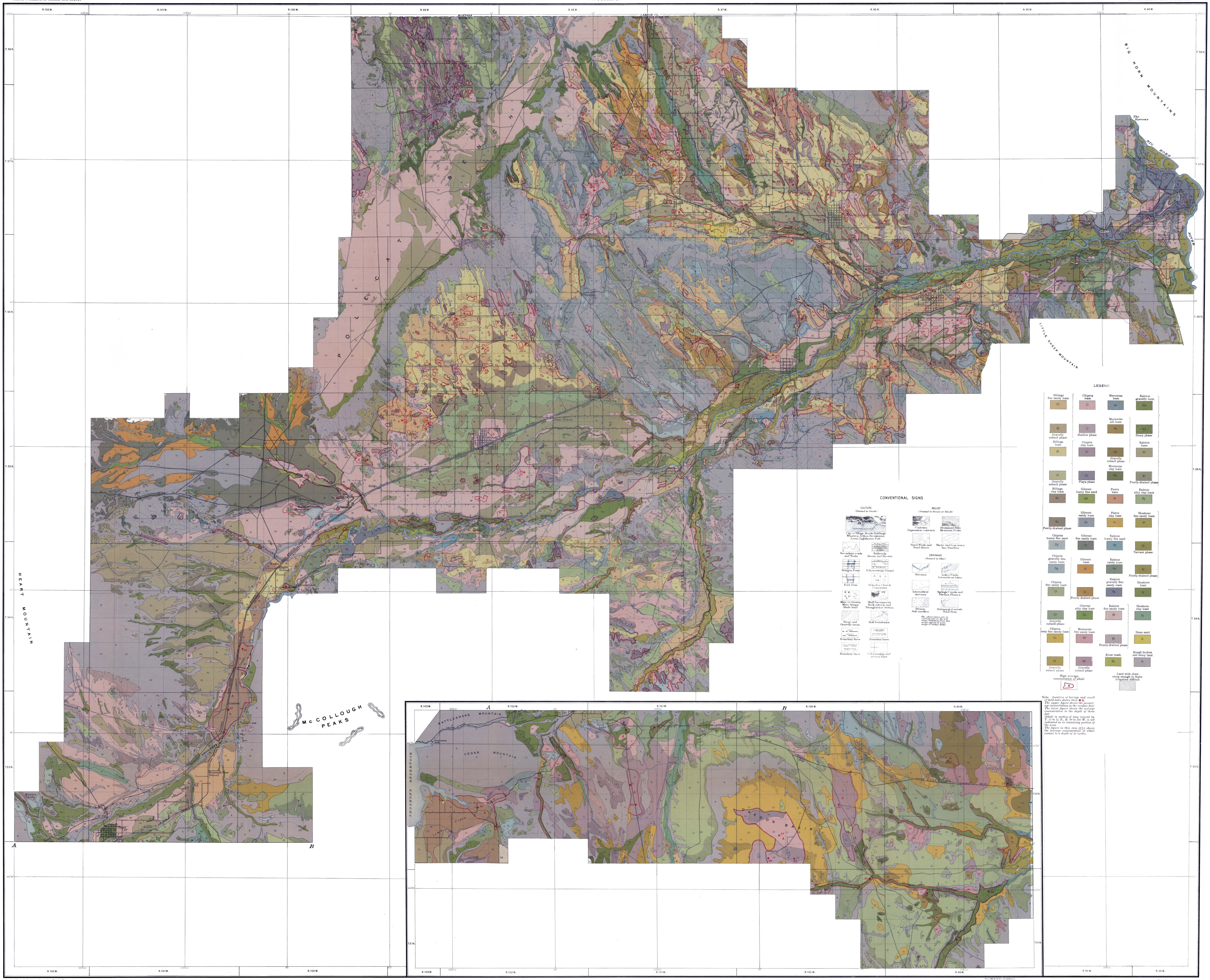
A. F. VASS, HEAD, DIVISION OF AGRONOMY



Macy H. Lapham, Inspector, District 5.
Soils surveyed by T. J. Dunnewald, in charge, and Carl Pearson.